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Further lectotypifications and nomenclatural notes on Rhamnaceae from northern Australia

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Abstract: The nomenclature and typification of seven species names of Rhamnaceae is discussed and lectotypes are chosen for *Rhamnus napalensis* (Wall.) M.A.Lawson, *Schistocarpaea johnsonii* F.Muell. and *Ventilago pubiflora* C.T.White, and the synonym *Rhamnus javanica* Miq. The lectotype of *Colubrina asiatica* (L.) Brongn. is corrected. A table is presented of the publication details for types and lectotypes of all taxa of Australian Rhamnaceae, excluding the tribe Pomaderreae, and the status of the genus *Dallachya* F.Muell. is discussed. The following species are illustrated: *Rhamnella vitiensis* (Benth.) A.C.Sm. and *Rhamnus napalensis*, *Sageretia hamosa* (Wall.) Brongn., *Schistocarpaea johnsonii*, *Ventilago ecorollata* F.Muell. and *V. pubiflora*.

Keywords: Nomenclature, typification, Rhamnaceae, Rhamneae, Ventilagineae, northern Australia

Introduction

With over 250 species, Australia is home to about one quarter of the world's species of Rhamnaceae. Most of these belong to one tribe, Pomaderreae Reissek ex Endl. (Kellermann *et al.* 2005; Kellermann 2007), but 14 genera with 28 species are from a variety of other tribes or are currently *incertae sedis*, according to the most recent family classification (Richardson *et al.* 2000b). A detailed overview of the tribes and genera can be found in Medan & Schirarend (2004).

During the preparation of the *Flora of Australia* treatment of Rhamnaceae, it became evident that lectotypes still needed to be chosen for the names of several non-Pomaderreae taxa. While most accepted names and synonyms have recently been typified, as listed in Table 1, a further four names are lectotypified in this paper. The taxa discussed here belong to the tribes Rhamneae and Ventilagineae; two species are from genera that are *incertae sedis*, i.e. not placed into a tribe by Richardson *et al.* (2000b).

McNeill (2014) clarified when lectotypification is necessary and his advice is followed in this paper. In some instances, this just confirms common practice, i.e. that the type is the specimen found in the institution where a botanist worked. In other cases, a variety of potential type specimens are available. Synonyms are only listed in this paper if they have been used in Australia (APC 2020; APNI 2020). All types have been examined, unless indicated by "*n.v.*"; those that were seen online via JSTOR Global Plants and other websites are indicated by "photo seen".

Nomenclature

Rhamnaceae trib. **Rhamneae** Horan.

Char. Ess. Fam. 138 (1847). Hook.f. in Benth. & Hook.f., *Gen. Pl.* 1: 373 (1862), emend. J.E.Richardson, *Kew Bull.* 55: 333 (2000). — **Type:** *Rhamnus* L.

The tribe Rhamneae is distributed throughout most of the world, except the Arctic and Antarctic regions. It contains 17 genera, of which three genera and four species are present in Australia: *Rhamnus* L., *Rhamnella* Miq. and *Sageretia* Brongn. (Tab. 1).

The typification of the three species native to Australia is treated in this paper; they all occur in eastern Queensland and are illustrated in Fig. 1. The introduced *Rhamnus alaternus* L. is widely naturalised in temperate regions of the Australian mainland and Tasmania (Walsh & Udovicic 1999).

Rhamnella vitiensis (Benth.) A.C.Sm.

Bull. Torrey Bot. Club 70: 544 (1943). — *Rhamnus*(?) *vitiensis* Benth., *Fl. Austral.* 1: 413 (1863). — *Dallachya vitiensis* (Benth.) F.Muell., *Fragm.* 9: 140 (1875). — **Lectotype:** Cape York, 12 Nov. 1849, *J. MacGillivray* "Voyage of Rattlesnake Bot. 511" (K000356672, ex herb. Hooker; photo seen), *fide* Kellermann & K.R.Thiele, *J. Adelaide Bot. Gard.* 22: 33 (2008). **Residual syntype:** Cape York, 14 Nov. 1849, *J. MacGillivray* "Voyage of Rattlesnake Bot. 511" (K000356671, ex herb. Hooker; photo seen).

Colubrina vitiensis Seem., *Syn. Pl. Vit.* 4 (1862), *nom. nud. & inval.*

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Fig. 1. The species of the tribe *Rhamneae* in Australia. **A–C** *Sageretia hamosa*: **A** habit ×0.3; **B** flower ×13; **C** fruit ×4. **D–F** *Rhamnus napalensis*: **D** habit ×0.6; **E** flower ×20; **F** fruit ×4. **G–I** *Rhamnella vitiensis*: **G** habit ×0.6; **H** flower ×13; **I** fruit ×4. — A–B *E. Volck 1415 & S.J. Dansie* (CANB226564), C *B. Hyland 15088* (CANB462077), D–F *T. Hartley 14115 & B. Hyland* (CANB250802), G–H *A. Thozet 255* (MEL2103509), I *I. Telford 9396 & G. Butler* (CBG8301615). Illustration by Anita Barley.

The most recently published phylogenies of the family Rhamnaceae are still inconclusive regarding the placement of this species, i.e. whether it should be recognised in the monotypic genus *Dallachya* F.Muell. or included in *Rhamnella* Miq. Hauenschild *et al.* (2016) and Hauenschild *et al.* (2018a) analysed the whole family and place *R. vitiensis* (Pacific, New Guinea and eastern Australia) in a clade with species of *Rhamnella* (China, Japan, Korea) and *Berchemiella* Nakai (China, Japan), but there was no statistical support for the inclusion of *Dallachya* into *Rhamnella*, as advocated by Smith (1943), or for its retention as a separate genus. Islam & Guralnick (2015) also recovered that clade, but since they only included one species of *Berchemiella* and *Rhamnella* each, their results are also not conclusive.

Kellermann & Thiele (2008) accepted *Dallachya* as a separate genus for Australia, following the only current worldwide treatment of Rhamnaceae by Medan & Schirarend (2004). This was based on morphological evidence, such as the lack of endosperm in *Dallachya*, compared to *Rhamnella*. In addition, wood anatomical characters seem to separate *R. vitiensis* from *Rhamnella* (Schirarend 1991); Islam & Guralnick (2015) also listed a number of characters that are different between *R. vitiensis* (the type of *Dallachya*) and *R. franguloides* (Maximov.) Weberb. (the type of *Rhamnella*) in their analysis of the tribe Rhamneae.

The consensus of the major Australian state and territory herbaria, as represented by the APC (2020), was to retain the species in *Rhamnella* as *R. vitiensis*. In light of preliminary phylogenetic data analysing the whole family (Tingshuang Yi & Qin Tian, pers. comm.), this seems to have been the right decision.

Smith (1985: 699) stated that "the type is *MacGillivray* (K HOLOTYPE, 2 sheets), collected Nov. 12 and 14, 1849", but since this citation refers to gatherings made on two different dates it does not constitute inadvertent typification of the name (Art. 9.10; Turland *et al.* 2018). The lectotype was first correctly designated by Kellermann & Thiele (2008: 33), who unambiguously chose one of these sheets, although they omitted the collection number in their publication. The collection number is clearly indicated on the specimens as "Voyage of Rattlesnake Bot. 511". Despite this, the second specimen is a syntype, rather than an isolectotype.

Rhamnus napalensis (Wall.) M.A.Lawson

in Hook.f., *Fl. Brit. India* 1: 640 (1875), as "*nipalensis*". — *Ceanothus napalensis* Wall. in W. Roxburgh, *Fl. Ind.* 2: 375 (1824), as "*napalansis*". — *Colubrina napalensis* G.Don, *Gen. Hist.* 2: 36 (1832), as "*nipaulensis*". — **Type citation:** "I have found this on various hills in the valley of Nipal, flowering in May, in fruit in June. In the Hon. Company's botanic gardens it blossoms and produces fruit during the same months". — **Lectotype (here designated):** Napalia, 1821, *N. Wallich 4263a* (K000618096, East India Company Herb.; photo seen). **Isolectotypes:** BM000793347, K000723153, M0211824 (photos seen). **Residual syntype:** "Ex Napalia introd., Hort. Bot. Calc.", 1823 (K000618097, East India Company Herb.; photo seen). **Excluded specimen:** Hort. Calc. [Botanic Gardens, Calcutta, India], cult., 1831, *N. Wallich 4263b* (K000723154; photo seen).

Rhamnus javanica Miq., *Fl. Ned. Ind.* 1(1): 646 (1855). — **Type citation:** "in Herb. Horsf.", "Java, door Dr. Th. Horsfield ontdekt." — **Lectotype (here designated):** "Rham. 6", Java, *T. Horsfield 444* (K000723161, Herb. Horsfield, purchased 1859; photo seen). **Isolectotypes:** "Rh. 6", *T. Horsfield s.n.* (K000723162, Herb. Javanicum; photo seen); Java, *Horsfield s.n.* (L0013767, fragment; photo seen). **Possible syntypes:** Java, Mt. Prahu, *T. Horsfield s.n.* (BM ×2 *n.v.*, *fide* J.G. West, pers. comm.).

Wallich (1828–1849) lists two collections of *Ceanothus napalensis*, as he states in the protologue (Roxburgh *et al.* 1824): no. *4263a* was collected in the field in Nepal; no. *4263b* was prepared from plants in cultivation at the Calcutta Botanic Gardens. Duplicates of these collections can be found in several herbaria, but the main set of Wallich's herbarium is at K. The specimen from Wallich's East India Company Herbarium (EICH) is selected as lectotype. Two cultivated specimen are at K, the one in EICH was collected in 1823 and is a syntype, the other specimen was collected in 1831, after the publication of the taxon.

Miquel (1855) described *Rhamnus javanica* from material from Thomas Horsfield's herbarium. A specimen from K annotated as coming from Horsfield's own collection is selected as lectotype of the name. Two specimens from BM are listed as possible syntypes, as the location details are slightly different to the lecto- and isolectotypes.

Common orthographic variants are "*nepalensis*" (e.g. King 1877), "*nipalensis*", "*nipaulensis*" and "*napalansis*" (see above). The Latin name for Nepal is "Napalia" and that has also been used by Wallich in his other publications, e.g. in the title of *Tentamen florae Napalensis illustratae* (Wallich 1824–1826) and extensively in the descriptions of Wallich (1830–1832). Wallich also coined 10 species names with the epithet "*napalensis*" (e.g. *Gouania napalensis* Wall., *Passiflora napalensis* Wall.; see IPNI 2020), the spelling "*napalansis*" in the protologue of *R. napalensis* seems to have been an error.

Sageretia hamosa (Wall.) Brongn.

Mém. fam. Rhamnées 53 (1826). — *Ziziphus hamosa* Wall. in W.Roxburgh, *Fl. Ind.* 2: 369 (1824). — *Berchemia hamosa* (Wall.) Wall., *Numer. List* n. 4253 (1831). — **Lectotype:** Napalia, 1821, *N. Wallich 4253a* (K001038526, East India Company Herb.; photo seen), *fide* B.M.Wadhwa, *Fl. Ceyl.* 10: 381 (1996), as "Type" (Art. 9.10). **Isolectotypes:** K000729256, P01818874 (photos seen); CAL *n.v.*, *fide* B.M.Wadhwa, *Fl. Ceyl.* 10: 381 (1996). **Excluded specimens:** Hort. Calc. [Botanic Gardens, Calcutta,

Fig. 2. Two species of the tribe Ventilagineae (A–F) and one species *incertae sedis* (G–I). **A–C** *Ventilago pubiflora*: **A** flowering branch ×0.6; **B** flower ×7.5; **C** fruit ×2. **D–F** *V. ecorollata*: **D** flowering branch ×0.6; **E** flower ×7.5; **F** fruit ×2. **G–I** *Schistocarpaea johnsonii*: **G** branch ×0.6; **H** flower ×7.5; **I** fruit ×2. — A, B *A.R. Bean 6752* (MEL1619038), C *N. Gibson 144* (BRI-AQ0349247), D *L.S. Smith 3820* (BRI-AQ0012251), E *F. Mueller* (MEL2105102), F *G. Sankowsky & N. Sankowsky 1266* (BRI-AQ0508619), G, H *V.K. Moriarty 1439* (BRI-AQ0109757), I *P.I. Forster PIF10718, G. Sankowsky & M.C. Tucker* (BRI-AQ0549556). Illustration by Anita Barley.

India], 1831, *N. Wallich 4253b* (K001038527, K000729255; photos seen); India, *N. Wallich 4253* (PH00007727, ex Herb. Schweinitz; photo seen).

Wadhwa (1996) inadvertently lectotypified the name with a specimen from "K-W", i.e. the Wallich herbarium (EICH). His use of the term "type" is to be corrected to "lectotype" (Art. 9.10; Turland *et al.* 2018). Isolectotypes can be found in the general collection at K and in several other herbaria.

While many of the new names in Wallich (1828–1849) are not validly published (Mabberley 1980), this is not the case for *Berchemia hamosa*, as Wallich clearly indicates "sub Zizipha", meaning that the species has previously been described in the genus *Ziziphus*, i.e. the basionym is *Z. hamosa*.

The Wallich specimens no. *4253b*, collected at the Calcutta botanic gardens in 1831 (i.e. some years after the publication of *Ziziphus hamosa*), are types of *Sageretia wallichii* Bhand. & Bhans.

Rhamnaceae trib. **Ventilagineae** Hook.f.

in Benth. & Hook.f., *Gen. Pl.* 1: 372 (1862). — **Type:** *Ventilago* Gaertn.

This tribe occurs in the Old World tropics and consists of two closely related genera, *Ventilago* Gaertn. and *Smythea* Seem. (the latter recently revised by Cahen & Utteridge 2018). The genus *Ventilago* is present in Australia with three species of vines or small trees (Tab. 1).

The nomenclature of two species is discussed below, the third taxon, *Ventilago ecorollata* F.Muell. was lectotypified in Kellermann & Thiele (2008). *Ventilago ecorollata* and *V. pubiflora* C.T.White are illustrated in Fig. 2A–F, line drawings of the more common *V. viminalis* can be found in Maiden (1903) and Latz (1995).

Ventilago pubiflora C.T.White

Proc. Roy. Soc. Queensland 50: 71 (1939). — **Type citation:** "Burnett District. – Biggenden, C.T. White, No. 7333 (type: advanced flowers and young fruits), 11 October, 1930 (vine growing over trees, common in second growth rain-forest, on the Biggenden–Childers road)". — **Lectotype (designated here):** Biggenden-Childers road, Qld, 11 Oct. 1930, *C.T. White 7333* (BRI-AQ317634, on 3 sheets; photos seen). **Isolectotypes:** K000681982 (photo seen), MEL713788.

White (1939) clearly stated that his collection *C.T. White 7333* is the type of the species. There are several specimens of this collection available at BRI, K and MEL. The BRI specimen has always been treated as, and is annotated as the "holotype". However, following McNeill (2014), lectotypification is necessary, as only the gathering, but not the actual specimen or herbarium was indicated by White. The lectotype, BRI-AQ317634, is a multi-sheet type and mounted on three herbarium sheets (Art. 8.3; Turland *et al.* 2018).

Ventilago viminalis Hook.

in T.L. Mitchell, *J. Exped. Trop. Australia* 369 (1848). — **Type citation:** "Tree 20 feet high, growing on high sandy ridges"; Mitchell states that the plant was collected between camps 76 and 77, more than 20 miles [32 km] west of Mount Bindango. **Lectotype:** "Sub-Tropical New Holland / Tree 20 feet high. High sandy ridges. / same as nr° 447 et 476" [near the Maranoa River, south of Mitchell, Qld], 24 Oct. 1846, *T. Mitchell 370* (K000681981, ex Herb. Hooker; mounted with K000681980 and Hooker's descriptive slip), *fide* J.Kellermann & K.R.Thiele, *J. Adelaide Bot. Gard.* 22: 35 (2008). **Residual syntypes:** "Sub-Tropical New Holland", 1846, *T. Mitchell 447* (K000681980, ex Herb. Hooker; mounted with K000681981); "Sub-Tropical New Holland / Tree 20 feet high, growing on high sandy ridges.", 1846, *T. Mitchell 447* (NSW505161); "Sub-Tropical New Holland", 1846, *T. Mitchell s.n.* (K000681979, ex Herb. Bentham; with handwritten Latin description of flower).

Kellermann & Thiele (2008) designated a lectotype for the name, but did not indicate the herbarium barcode number. They quoted the label information incorrectly as "Subtropical Australia" and did not list any other type specimens.

The lectotype has Hooker's description attached to it, on which he comments on the collections: "447 et 476 same as n. 370", i.e. he prepared his description from all three collections. The type sheet contains two of these, the lectotype *Mitchell 370*, a small specimen displaying the typical winged fruits, as well as the syntype *Mitchell 447*, a larger flowering branch. A duplicate of the latter specimen can be found at NSW. The lectotype and the NSW specimen have labels with specific information on tree height and habitat that is mentioned in the protologue. There is another syntype at K, a flowering branch also collected by Thomas Mitchell during the same expedition, but without a collecting number. The specimen with the collecting number 476, which is mentioned in Hooker's note, could not be found, but it is possible that this is the unnumbered syntype at K (K000681979).

Interestingly, *Ventilago viminalis* is one of the only species of Australian Ramnaceae that is naturalised overseas; it is found in northern Africa (Jafri 1977; Alzerbi *et al.* 2020).

Genera *incertae sedis*

Several genera of Rhamnaceae are not assigned to tribes due to a lack of molecular evidence (Richardson *et al.* 2000a, b). More recent phylogenies resolved some relationships of these genera, but the backbone of the trees, i.e. the relationships of these genera to other tribes

Table 1. Typification of genera and species of Australian Rhamnaceae, excluding the tribe Pomaderreae. If the typification is discussed or amended in other publications, this is indicated (with "see"). Types of genera are listed in accordance with Farr & Zijlstra (1996–); genera that were monotypic at the time of publication and, as such, automatically typified are also indicated.

Taxon	Typifying publication
tribe COLLETIEAE	
Discaria Hook.	Pfeiffer (1871–1875); see Kellermann & Udovicic (2020)
Discaria nitida Tortosa	Kellermann & Udovicic (2020)
Discaria pubescens (Brongn.) Druce	Kellermann & Udovicic (2020)
tribe GOUANIEAE	
Gouania Jacq.	Pfeiffer (1871–1875)
Gouania australiana F.Muell.	Kellermann & Thiele (2008)
Gouania exilis K.R.Thiele	Thiele & West (1995)
tribe PALIUREAE	
Ziziphus Mill.	Britton & Wilson (1924)
Ziziphus mauritiana Lam.	Johnston (1972); see Kellermann (2020a)
Ziziphus oenopolia (L.) Mill.	Trimen (1887) & Johnston (1972); see Kellermann (2020a)
Ziziphus quadrilocularis F.Muell.	Kellermann (2020a)
Ziziphus timoriensis DC.	Kellermann (2020a)
Hovenia Thunb.	Monotypy
Hovenia dulcis Thunb.	Sen Gupta & Safui (1984); see Kellermann (2020a)
tribe PHYLICEAE	
Noltea Rchb.	Monotypy
Noltea africana (L.) Endl.	Wijnands (1983)
tribe RHAMNEAE	
Rhamnella Miq.	Monotypy
Rhamnella vitiensis (Benth.) A.C.Sm.	Kellermann & Thiele (2008); see this paper
Rhamnus L.	Britton & Brown (1913)
Rhamnus alaternus L.	Jafri (1977)
Rhamnus napalensis (Wall.) M.A.Lawson	This paper
Sageretia Brongn.	Pfeiffer (1871–1875)
Sageretia hamosa (Wall.) Brongn.	Wadhwa (1996); see this paper
tribe VENTILAGINEAE	
Ventilago Gaertn.	Monotypy
Ventilago ecorollata (F.Muell.) F.Muell.	Kellermann & Thiele (2008)
Ventilago pubiflora C.T.White	This paper
Ventilago viminalis Hook.	Kellermann & Thiele (2008); see this paper
genera incertae sedis	
Colubrina Rich. ex Brongn.	Typ. cons.; Voss (1983)
Colubrina asiatica	Trimen (1887) & Johnston (1972); see this paper
Schistocarpaea F.Muell.	Monotypy
Schistocarpaea johnsonii F.Muell.	This paper
***genera incertae sedis — ALPHITONIA* GROUP**	
Alphitonia Reissek ex Endl.	Monotypy
Alphitonia excelsa (A.Cunn ex Fenzl) Reissek ex Benth.	Bean (2010) & Kellermann (2020b)
Alphitonia oblata A.R.Bean	Bean (2010); see Hauenschild *et al.* (2018b)
Alphitonia petriei Braid & C.T.White	Braid (1925) & Kellermann (2020b)
Alphitonia pomaderroides (Fenzl) A.R.Bean	Bean (2006) & Kellermann (2020b)
Alphitonia whitei Braid	Braid (1925) & Bean (2010); see Kellermann (2020b)
Emmenosperma F.Muell.	Monotypy
Emmenosperma alphitonioides F.Muell.	Kellermann & Thiele (2008); see Hauenschild *et al.* (2018b)
Emmenosperma cunninghamii Benth.	Kellermann (2020b)
Emmenosperma pancherianum Baill.	Bean (2013); see Hauenschild *et al.* (2018b)
Granitites Rye	Monotypy
Granitites intangendus (F.Muell.) Rye	Rye (1996); see Hauenschild *et al.* (2018b)

and genera, was generally not well supported (Onstein *et al.* 2015; Hauenschild *et al.* 2016, 2018a).

The nomenclature of two genera, *Colubrina* Rich. ex Brongn. and *Schistocarpaea* F.Muell., is treated below; the four genera of the *Alphitonia* Group (see Tab. 1) are discussed in Kellermann (2020b). *Schistocarpaea johnsonii* is shown in Fig. 2G–I, *Colubrina asiatica* was illustrated in Rye (1997).

Colubrina asiatica (L.) Brongn.

Mém. fam. Rhamnées 62 (1826). — *Ceanothus asiaticus* L., *Sp. Pl.* 196 (1753). — **Type citation:** "*Fl. zeyl* 98 * Habitat in Zeylona ħ"[1]. **Lectotype:** Ceylon, *Herb. Hermann* 2.11 no. 98 (BM000621540; photo seen), *fide* Trimen, *J. Linn. Soc., Bot.* 24: 138 (1887), *et* M.C.Johnst., *Brittonia* 23: 47 (1971). **Residual syntypes:** *Herb. Hermann* 2.33 no. 98 (BM000621626, photo seen); *Herb. Hermann* 2.78 no. 98 (BM000621768, photo seen).

Ceanothus capsularis G.Forst., *Fl. Ins. Austr.* 18 (1786). — *Pomaderris capsularis* (G.Forst.) G.Don ex Loud., *Hort. Brit.* 84 (1830). — *Trymalium capsulare* G.Don, *Sweet's Hort. Brit. ed. 3,* 137 (1839). — *Pomaderris capsularis* Montrouz., *Mém. Acad. Roy. Sci. Lyon, Sect. Sci.* 10: 193 (1860), *nom. illeg.* — **Holotype:** Tahiti, *G. Forster s.n.* (BM000838461, photo seen), *fide* M.C.Johnston, *Brittonia* 23: 47 (1971).

As discussed in Kellermann (2020a), the publication by Trimen (1887) was overlooked by Jarvis (2007, 2016) when listing lectotypes from the Hermann Herbarium. Jarvis stated that the lectotype was first designated by Fawcett & Rendle (1926), however Trimen (1887) already clearly associated Hermann Herbarium no. 98 with the name *Ceanothus asiaticus* and listed it as the type. There are three specimens of that collection present in vol. 2 of the herbarium, on pages 11, 33 and 78. Johnston (1971) limited the lectotype to the specimen on p. 11, in a second-step lectotypification (Art. 9.17; Turland *et al.* 2018).

No other specimen of *Ceanothus capsularis* could be found, i.e. the listing of the BM specimen as "holotype" by Johnston (1971) is here accepted.

Within *C. asiatica* there are currently two recognised varieties (POWO 2020). Plants in Australia can be referred to *Colubrina asiatica* var. *asiatica*.

Schistocarpaea johnsonii F.Muell.

Vict. Naturalist 7: 183 (1891), as "*johnsoni*". — **Type citation:** "On Mount Bartle-Frere; Stephen Johnson". **Lectotype (here designated):** Mount Bartle-Frere, [Jan.] 1891, *S. Johnson s.n.* (MEL713013). **Isolectotypes:** MEL2290283; K000729229.

There are two specimens of this taxon at the National Herbarium of Victoria (MEL), where Mueller worked, and one at K. The MEL specimen with the most flowers is selected here as the lectotype. It is annotated as "holotype" by K.R. Thiele, but since there is more than one specimen available, lectotypification is warranted (McNeill 2014). The label of the other specimen (MEL2290283) also mentions the month of collection in addition to the year: January 1891. The Kew duplicate has exactly the same blue "Phytologic Museum of Melbourne" label as the lectotype.

The speed of publication is quite remarkable: Johnson collected the specimens in Jan. 1891 and Mueller published the description of a new genus and species in March of the same year.

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1 Linnaeus indicates good quality illustrations with an asterisk (*); the symbol ħ denotes shrubs.

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The other 'propeller plant' – Notes on *Stenanthemum* Reissek (Rhamnaceae: Pomaderreae) and a key to the genus in Australia

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Abstract: Descriptions are provided for ten taxa of *Stenanthemum* Reissek published in the 19th century and their typification is clarified. Lectotypes are chosen for *St. divaricatum* (Benth.) Rye, *St. humile* Benth., *St. leucophractum* (Schltdl.) Reissek, *St. pimeleoides* (Hook.f.) Benth., *St. pumilum* (F.Muell.) Diels and *Cryptandra* subgen. *Solenandra* Reissek (a synonym of *Stenanthemum*). A key to all species and subspecies of the genus, which is endemic in Australia, is provided.

Keywords: Nomenclature, typification, identification key, Rhamnaceae, Pomaderreae, *Stenanthemum*, Australia

Introduction

Stenanthemum Reissek contains c. 30 species, most endemic to Western Australia (Rye 1995, 2001, 2007), but eight species occur in other States, as outlined in Thiele (2007). The taxonomic history of the genus was discussed in Kellermann (2007) and Thiele (2007).

The genus was described by Reissek (1858), who included four species that were previously published in *Cryptandra* Sm.: *St. leucophractum* (Schltdl.) Reissek, *St. pomaderroides* (Reissek) Reissek, *St. coronatum* (Reissek) Reissek and *St. tridentatum* (Steud.) Reissek. The latter three were originally grouped in *Cryptandra* sect. *Solenandra* Reissek (1848). In subsequent years, however, *Stenanthemum* was not accepted by Ferdinand von Mueller, who included it in *Spyridium* Fenzl (Mueller 1862) or *Cryptandra* (Mueller 1875, 1882).

Hooker (1862) recognised the genus, albeit with a different circumscription, excluding species with a shorter floral tube; Bentham (1863) listed these short-tubed taxa under *Spyridium* in the *Flora Australiensis*, as *Sp. tridentatum* (Steud.) Benth., *Sp. divaricatum* Benth. and *Sp. complicatum* F.Muell. In addition to the first three *Stenanthemum* species of Reissek (1858) mentioned in the previous paragraph, Bentham's (1863) treatment of *Stenanthemum* also included *St. pimeleoides* (Hook.f.) Benth., *St. humile* Benth. and *St. waterhousei* (F.Muell.) Benth. However, the latter species is actually a species of *Spyridium* Fenzl. (Kellermann 2007).

The concept of Hooker (1862) and Bentham (1863) was generally followed by subsequent authors, but Mueller (1875) still included the genus in *Spyridium* when describing *Sp. pumilum* F.Muell., a species that Diels & Pritzl (1904) transferred to *Stenanthemum* as *St. pumilum* (F.Muell) Diels.

From the early years of the 20th century, *Stenanthemum* was not accepted any more by Australian botanists, with the species mostly subsumed under *Cryptandra* and *Spyridium* (e.g. Black 1926, 1952; Gardner 1931; Suessenguth 1953; Blackall & Grieve 1956; Curtis 1956; Willis 1973; Conn 1983; Canning & Jessop 1986). There was also a hiatus in the description of new species.

Rye (1995), in a re-evaluation of all genera of Rhamnaceae in Western Australia, re-instated *Stenanthemum* and described 21 new species and subspecies (Rye 1995, 2001, 2007). Bean (2004) published a new species from Queensland, *St. argenteum* A.R.Bean. Thiele (2007) clarified the generic limits between *Spyridium*, *Cryptandra* and *Stenanthemum*, reviewed all species occurring outside Western Australia, and described two new species.

While Rye (1995, 2001, 2007) provided detailed descriptions of all her new taxa, she did not give descriptions for already existing species. Thiele (2007) provided descriptions of two of these species, *St. leucophractum* and *St. pimeleoides*. A key to species in Western Australia was published by Rye (2007) and a key for the rest of Australia by Thiele (2007).

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Rye (2001, 2007) also described an unusual taxon, *St. sublineare* Rye, which does not fully agree with the generic circumscription of *Stenanthemum*. The question as to whether this taxon should be separated into another genus, in view of a few unique characters noted by her, or remain in *Stenanthemum*, is the subject of current research.

In this paper, ten taxa of *Stenanthemum*, first published in the 19th century, are typified and provided with modern descriptions based on available material. A combined key for the whole of Australia is also presented here; this is also available on KeyBase (https://keybase.rbg.vic.gov.au/). Note that authorities for the taxa in the key can be found in APNI (2020).

McNeill (2014) clarified some misconceptions about holotypes and procedures for lectotypification, and his advice is followed in this paper. All type specimens have been examined; those that were seen online via JSTOR Global Plants and other websites are indicated by "photo seen". Rye (1995) mentions some types for previously published species. This can be regarded as inadvertent typification, and her use of the term "type" or "holotype" is corrected to "lectotype" (Art. 9.10; Turland *et al.* 2018) in the species treatments below. This correction is possible, as before 2001 it was not necessary to use the phrase "here designated" when lectotypifying names (Art. 7.11).

The common name 'propeller plant' is applied to two species of Australian Rhamnaceae: the more widespread *Spyridium vexilliferum* (Hook.) Reissek from Tasmania, Victoria and South Australia (also called 'helicopter bush' and 'winged spyridium'), and to *Stenanthemum pimeleoides*, endemic to Tasmania (which is also called 'spreading stenanthemum'). In both cases the common name refers to the propeller-like white felty floral leaves that surround the inflorescence (Wapstra *et al.* 2010).

Nomenclature

Stenanthemum Reissek

Linnaea 29: 295 (1858). — *Spyridium* sect. *Stenanthemum* (Reissek) F.Muell., *Fragm.* 3: 77 (1863), *nom. inval.* — *Cryptandra* sect. *Stenanthemum* (Reissek) F.Muell., *Fragm.* 3: 77 (1862). Suess., *Nat. Pflanzenfam.* (2nd edn) 20d: 118 (1953). — **Type:** *Stenanthemum leucophractum* (Schltdl.) Reissek, *fide* Rye, *Nuytsia* 13: 496 (2001).

Cryptandra sect. *Stenocodon* Hook.f., *Bot. Antarct. Voy III (Fl. Tasman.)* 1: 75 (1855). — **Type:** *Cryptandra pimeleoides* Hook.f. ≡ *Stenanthemum pimeleoides* (Hook.f.) Reissek. (typification by monotypy).

Cryptandra subgen. *Solenandra* Reissek in Lehm., *Pl. Preiss.* 2: 288 (1848). — *Solenandra* (Reissek) Kuntze, *Revis. Gen. Pl.* 1: 120 (1891), *nom. illeg.*, *nom. superfl.*, *non* Hook.f. in Benth. & Hook.f., *Gen. Pl.* 2: 12, 43 (1873) (Rubiaceae). — *Cryptandra* sect. *Solenandra* (Reissek) T.Post & Kuntze, *Lex. Gen. Phan.* 150 (1903). — **Lectotype (here designated):** *Cryptandra pomaderroides* Reissek. ≡ *Stenanthemum pomaderroides* (Reissek) Reissek.

Note. Hooker (1855) segregated the only species of *Stenanthemum* in Tasmania (Tas.), described by him as *C. pimeleoides* Hook.f., in a separate section of *Cryptandra*, i.e. sect. *Stenocodon* Hook.f.

Kuntze (1891) published the superfluous *Solenandra* to replace *Stenanthemum*, since he was of the opinion that *Cryptandra* subgen. *Solenandra* Reissek should have retained its name when Reissek raised it to generic rank. By doing this, however, Kuntze created an illegitimate name due to the presence of the earlier homonym *Solenandra* Hook.f. (Rubiaceae).

Typification. Reissek (1848) included three species in *Cryptandra* subgen. *Solenandra*, all of which are now in *Stenanthemum*: *St. pomaderroides*, *St. coronatum* and *St. tridentatum*. The first of these is designated as the lectotype. It has a glabrous ovary summit, as well as an inconspicuous floral disc, both of which are the defining characters of Reissek's subgenus.

1. *Stenanthemum complicatum* (F.Muell.) Rye

Nuytsia 10: 282 (1995). — *Spyridium complicatum* F.Muell., *Fragm.* 3: 78 (1862). — *Cryptandra complicata* (F.Muell.) F.Muell., *Syst. Census Austral. Pl.* 61 (1883). — **Type citation:** "In planitiebus arenosis apud fodinas Geraldinae ad flumen Murchsion. Oldfield." — **Lectotype:** Sand plain, nr Yanarie / Murchison River, W.A., *s.d.*, *A.F. Oldfield s.n.* (MEL90946), *fide* Rye, *Nuytsia* 10: 282 (1995), as "holo". **Isolectotype:** Murchison River, *A.F. Oldfield s.n.* (K001096741, Herb. F.Mueller, ex Herb. Hooker).

Illustrations: B.J. Grieve, *How to Know W. Austral. Wildfl.* (2nd edn) 2: 597 (1998).

Woody, straggling *shrub* to 2 m high, with densely rusty-pubescent young stems. *Leaves*: stipules broadly triangular, 1–3 mm long, free or shortly connate; petiole 1–5 mm long; lamina broadly obovate, (6–) 8–12 (–15) mm long, 4–8 mm wide, cuneate at base, flat or folded, apex obtuse to acute and recurved-apiculate, greyish-velvety above with short erect simple hairs, densely greyish- or rusty-villous or pubescent beneath. *Inflorescences* to 1 cm wide, with 10–50 flowers. *Flowers* densely white-woolly; free hypanthium tube 0.6–0.8 mm long, 0.8–1.5 mm diameter. *Sepals* 0.9–1.2 mm long. *Petals* 0.6–0.7 mm long, distinctly clawed. *Disc* inconspicuous. *Ovary* roof stellate-hairy; style 0.8–1.1 mm long. *Fruits* 2.5–3 mm long; seeds 1.5–1.7 mm long.

Distribution. Endemic to south-western Western Australia (W.A.), between Shark Bay and Mullewa, in shrublands and woodland on sand.

Phenology. Flowers and fruits Aug.–Oct.

Key to *Stenanthemum* in Australia

1. Ovary summit (around the style base inside the hypanthium tube) glabrous

2. Sepals glabrous; low shrubs with lignotuber; W.A. . . . . ***St. sublineare***

2: Sepals pubescent, woolly or villous; lignotuber absent

3. Low, densely-branched shrubs, stipules overlapping, sheathing the stems; sepals very densely white-woolly

4. Inflorescences subtended by white-tomentose floral leaves; Tas. . . . . 7. ***St. pimeleoides***

4: Inflorescences without subtending white-tomentose leaves; W.A.

5. Leaves linear, revolute, the margins often more or less meeting; stipules and floral bracts reddish-brown . . . . . 4. ***St. humile***

5: Leaves narrowly to broadly obovate, flat or folded, margins not recurved; stipules and bracts almost black

6. Lamina 4–14 mm long, the upper surface greyish and covered with dense simple hairs when young, retaining hairs at least near midrib, often staying hairy

7. Lamina 4–7 mm long; free hypanthium tube c. 1.5 mm long; Stirling Range . . . . . .9. ***St. pumilum*** subsp. ***pumilum***

7: Lamina (7.5–) 9–14 mm long; free hypanthium tube 1.8–2.6 mm long; Darling Range near Perth to Highbury . . . . . ***St. pumilum*** subsp. ***majus***

6: Lamina 8–17 mm long, the upper surface green, glabrous (even when young), sometimes with few hairs along the midvein . . . . . ***St. yorkense***

3: Openly branched shrubs, erect or prostrate; stipules not sheathing the stems; sepals appressed-pubescent to moderately woolly or villous

8. Stem leaves stellate-hairy above

9. Free hypanthium tube < 2 mm long

10. Flowers greyish woolly-hirsute; sepals 0.5–0.8 mm long; disc inconspicuous or if visible, then shallowly scooped between filaments; W.A. . . . . ***St. stipulosum***

10: Flowers silvery villous; sepals 1.2–1.4 mm long; disc conspicuous, deeply scooped between filaments; S.A. . . . . ***St. arens***

9: Free hypanthium tube > 2 mm long

11. Lamina 2–8 mm long; stipules connate for part of their length; white felty floral leaves absent; W.A.

12. Disc conspicuous; petioles 1–5 mm long . . . . . ***St. patens***

12: Disc apparently absent; petioles 0.5–1 mm long . . . . . ***St. poicilum***

11: Lamina (5–) 10–18 (–20) mm long; stipules free; inflorescences usually subtended by white floral leaves

13. Flowers silvery-villous; central Australia . . . . . ***St. centrale***

13: Flowers creamy-pubescent; south-west W.A. . . . . 8. ***St. pomaderroides***

8: Stem leaves glabrous, papillose, scabrid or simple-hispid or -velvety above

14. Leaf margins narrowly recurved or revolute; low spreading to prostrate shrubs

15. Inflorescences subtended by white floral leaves; bracts broad; Tas. . . . . 7. ***St. pimeleoides***

15: Inflorescences without white floral leaves; bracts broad or narrow-triangular; W.A.

16. Leaves deeply emarginate with an acute lobe on both sides of the leaf apex; bracts narrow-triangular . . . . . 2. ***St. coronatum***

16: Leaf apex rounded or slightly lobed; bracts broad, ± ovate . . . . . ***St. liberum***

14: Leaf margins ± flat; ± erect shrubs

17. Leaves distinctly emarginate or tridentate; W.A. . . . . 10. ***St. tridentatum***

17: Leaves acute to obtuse or shallowly emarginate, never tridentate

18. Upper leaf surface smooth, glabrous, villous or velvety with short, erect hairs

19. Lamina 10–15 mm long, velvety above; W.A. . . . . ***St. newbeyi***

19: Lamina 2–7 mm long, glabrous or sparsely villous above; S.A. . . . . ***St. arens***

18: Upper leaf surface finely papillose-tuberculate, glabrous or scabrid

20. Leaves narrowly obovate with a straight apex, folded only when young, soon flat; margins ± recurved; inflorescences not subtended by white felty floral leaves; W.A. . . ***St. reissekii***

20: Leaves narrowly to broadly obovate, mostly folded; apex recurved; margins flat; white floral leaves present, at least in some flower-heads

21. Leaves shining silvery beneath, never rusty; northern Qld . . . . . ***St. argenteum***

21: Leaves rusty beneath (at least when young)

22. Lamina 5–20 mm long; indumentum of flowers creamy; W.A. . . . 8. ***St. pomaderroides***

22: Lamina 3–9 mm long; indumentum of flowers white or greyish

23. Young stems villous; leaves densely villous beneath; sepals 1–1.2 mm long; eastern Australia . . . . . 5. ***St. leucophractum***

23: Young stems pubescent; leaves densely silky beneath with longer hairs along veins and margins; sepals 1.5–2 mm long; W.A. . . . . ***St. bremerense***

1: Ovary summit pubescent

24. Free hypanthium tube 2.5–3.0 mm long; W.A. . . . . ***St. limitatum***

24: Free hypanthium tube < 1.5 mm long

25. Leaves distinctly bilobed to tridentate or with sharp teeth either side of the apex; apex ± straight

26. Leaves glabrous to papillose or scabrid above

27. Leaf margins recurved to revolute; leaves narrow-obtriangular to almost flabellate; apex often deeply bilobed; W.A.

28. Plants often spinescent; inflorescences 1–3-flowered, strictly lateral . . . . . 3. ***St. divaricatum***

28: Plants not spinescent; inflorescences 2–15-flowered, terminal and lateral

29. Flowers with an indumentum of short appressed hairs; bracts and stipules sparsely hairy; lamina 1–2 (–5) mm wide . . . . . ***St. emarginatum***

29: Flowers, bracts and stipules with long spreading hairs; lamina 3–5 mm wide . . . ***St. radiatum***

27: Leaf margins ± flat; leaves obovate to broadly obovate; apex notched or emarginate or with several teeth either side of the apex

30. Sepals villous; W.A. . . . . ***St. nanum***

30: Sepals pubescent

31. Mature leaves hairy above; W.A., S.A., Vic. . . . . ***St. notiale*** subsp. ***notiale***

31: Mature leaves glabrous above; W.A. . . . . 6. ***St. notiale*** subsp. ***chamelum***

26: Leaves pubescent to hispid above

32. Leaves greyish stellate-hoary above, with or without overlying longer simple hairs

33. Leaf margins distinctly recurved, apex deeply bilobed, leaves not folded; flowers without a free hypanthium tube; W.A. . . . . ***St. bilobum***

33: Leaf margins flat or with slightly recurved margins, entire to recurved apiculate, usually folded; hypanthium tube to 0.4 mm long; W.A., S.A., Vic. . . . . ***St. notiale*** subsp. ***notiale***

32: Leaves simple-hispid above

34. Leaves flat or slightly recurved; sepals pubescent; disc above ovary roof level, shallowly scooped between the stamens

35. Leaves with 1–2 teeth on either side of the apex; petiole 0.3–1 mm long; lamina 2–4 (–10) mm long; W.A. . . . . ***St. intricatum***

35: Leaves usually entire, rarely with 1 tooth on either side of the apex (tridentate); petiole 0.5–2 mm long; lamina (3–) 5–8 (–13) mm long; W.A., S.A., Vic. . . . ***St. notiale*** subsp. ***notiale***

34: Leaves distinctly recurved; sepals villous; disc ± level with ovary roof; W.A . . . . . ***St. cristatum***

25: Leaves obtuse to acute and recurved-apiculate

36. Leaves glabrous and tuberculate above

37. Hypanthium densely woolly with white or greyish, spreading hairs; W.A., central Australia (N.T.) . . . . . ***St. petraeum***

37: Hypanthium villous or sericeous with ± appressed, silvery or rusty hairs; W.A. . . . . ***St. mediale***

36: Leaves hairy above, although hairs may be tubercle-based

38. Stipules fused for ± half of their length; W.A., S.A., Vic. . . . . ***St. notiale*** subsp. ***notiale***

38: Stipules free to the base or nearly so; W.A. . . . . 1. ***St. complicatum***

Note. This species shares with *Stenanthemum petraeum* Rye the densely hairy ovary summit, but differs in its more hairy stipules, greener leaves with minute patent simple hairs on the upper surface (*cf.* glabrous-tuberculate). The two species also occur in different habitats, with *St. complicatum* growing in sandy soils and *St. petraeum* preferring stony slopes. *Stenanthemum complicatum* is closely related to *St. stipulosum* Rye and *St. newbeyi* Rye.

Typification. The name was inadvertently lectotypified by Rye (1995). A duplicate of the specimen, sent by Mueller to Hooker, is in the Kew Herbarium.

Selected specimens examined
WESTERN AUSTRALIA. Tamala Rd on Nanga Station, Shark Bay, 26 Aug. 1973, *E.C. Nelson ANU17196* (CANB, PERTH); 25 km NE of Yuna, 8 Sep. 1962, *F.W. Went 51* (PERTH); ca 5 km N of Herald Bay outcrop, Dirk Hartog Island, 4 Sep. 1972, *A.S. George 11504* (CANB, PERTH); Kalbarri Natl Park, management track to sandpit, off road to Nature's Window & The Loop, 11 Sep. 2001, *J. Kellermann 240* (AD); Bindoo Hill Nature Reserve, 14 Sep. 2001, *J.Kellermann 267* (AD, CANB, MEL, PERTH).

2. *Stenanthemum coronatum* (Reissek) Reissek

Linnaea 29: 295 (1858). — *Cryptandra coronata* Reissek in Lehm., *Pl. Preiss.* 2: 288–289 (1848). — *Spyridium coronatum* (Reissek) F.Muell., *Fragm.* 9: 137 (1875). — *Solenandra coronata* (Reissek) Kuntze, *Revis. Gen. Pl.* 1: 121 (1891), as "*coronatum*". — **Type citation:** "Ad Swan River (Drummond. coll. II. No. 722)." — **Lectotype:** W.A., *J. Drummond 722* (MEL227036), *fide* B.L.Rye, *Nuytsia* 10: 282 (1995), as "type". **Isolectotypes:** Western Australia, *J. Drummond 722 (2nd coll.)* (BM000050758); Swan River, *J. Drummond 722* (K001096705, ex Herb. Bentham; K001096706, ex Herb. Saunders); Nouvelle Hollande occidentale, R. des cygnes (Swan River), 1843, *J. Drummond 722* (P06786201, photo seen); ?W (*n.v.*).

Illustrations: B.L. Rye, *Nuytsia* 10: 285, fig. 8A–C (1995); B.J. Grieve, *How to Know W. Austral. Wildfl.* (2nd edn) 2: 593 (1998).

Low spreading *shrub* to 10 cm high with sparsely stellate-hairy young stems. *Leaves*: stipules narrowly triangular, 2–3.5 mm long, connate for up to half of their length; petiole 1–1.5 mm long; lamina broadly obovate, 4–5 mm long, 3–4 mm wide, cuneate at base, with narrowly revolute margins, deeply emarginate with an acute lobe on either side of the apex, glabrous and scabrid above, villous below. *Inflorescences* to 1 cm wide, with 5–10 flowers. *Flowers* densely white-villous; free hypanthium tube c. 3 mm long, 1–1.2 mm diameter. *Sepals* 1.2–1.6 mm long. *Petals* 0.8 mm long, distinctly clawed. *Disc* conspicuous. *Ovary* roof glabrous; style 3.5–4 mm long. *Fruits* 2–2.3 mm long; seeds 1.5–1.7 mm long.

Distribution. Endemic to south-western W.A. between Bindoon and Narrogin, in woodland on laterite.

Phenology. Flowers Sep.–Nov.; fruits Nov.

Note. Populations from the northern part of the range tend to have coarser and/or longer hairs on the upper surface of the leaves. The species is closely related to *Stenanthemum nanum* Rye and *St. limitatum* Rye. It shares with them leaves that are toothed on each side of the apex and a disc that is deeply scooped between the stamen traces. This disc type is also present in *St. mediale* Rye and *St. reissekii* Rye.

Typification. The name was inadvertently lectotypified by Rye (1995). Duplicates of the Drummond specimen are in several herbaria, though only the label on the BM specimen mentions the 2nd collection, as indicated in the protologue. The date on the P specimen is also consistent with Drummond's 2nd collection (Barker 2004). Reissek worked in Vienna and it is possible that a specimen is in W, but none has been seen.

Selected specimens examined
WESTERN AUSTRALIA. Mokine Nature Reserve, 17 km SW of Northam, 6 June 1985, *G.J. Keighery & J.J. Alford 448* (PERTH); Mercer Rd, Talbot State Forest, SW of York, 21 Sep. 2001, *J. Kellermann 307 & F. Hort* (MEL, PERTH); Dryandra State Forest, 25 Nov. 1987, *D.M. Rose 541* (PERTH).

3. *Stenanthemum divaricatum* (Benth.) Rye

Nuytsia 10: 284 (1995). — *Spyridium divaricatum* Benth., *Fl. Austral.* 1: 427 (1863); *Cryptandra divaricata* (Benth.) F.Muell., *Syst. Census Austral. Pl.* 61 (1883), *nom. illeg.*, *non* Reissek in Lehm., *Pl. Preiss.* 2: 286 (1848). — **Type citation:** "W. Australia. Dirk Hartog's Island, *Milne* ; Murchison river, *Oldfield*". — **Lectotype (here designated):** Murchison River, W.A., *A.F. Oldfield s.n.* (MEL227041). **Isolectotypes:** K000732051 (ex Herb. Hooker, photo seen); MEL2277040. **Residual syntype:** Dirk Hartog Island, Voyage of H.M.S. Herald, *W.G. Milne s.n.* (K000732050, ex Herb. Hooker, annotated by Bentham, photo seen).

Illustrations: B.L. Rye, *op. cit.*, 283, fig. 7L–Q (1995); B.J. Grieve, *How to Know W. Austral. Wildfl.* (2nd edn) 2: 593 (1998).

Small, much-branched, often spinescent *shrub* to 20 cm high, with sparse, greyish, simple and/or stellate hairs on young stems and leaf undersurfaces. *Leaves*: stipules broadly triangular to rectangular, 0.8–1.2 mm long, connate; petiole 0.3–1 mm long; lamina flabellate to narrowly obovate, 3–8 mm long, 1.5–4 mm wide, cuneate at base, apex tridentate, with recurved to revolute margins, smooth and glabrous above. *Inflorescences* apparently lateral, to 0.5 cm wide, with 1–3 flowers. *Flowers* moderately to densely pubescent with greyish simple and/or stellate hairs; free hypanthium tube 0.1–0.2 mm long, 0.7–0.9 mm

Fig. 1. *Stenanthemum humile*, growing in Kwongan bushland, Hi Vallee Farm, Badgingarra (W.A.). **A** Flowering plant; **B** close up of flowering branches; **C** flower-heads, not surrounded by white floral leaves. — *J. Kellermann 195* (AD). Photos by J. Kellermann.

diameter. *Sepals* 0.7–1 mm long. *Petals* 0.5–0.6 mm long, indistinctly clawed. *Disc* inconspicuous. *Ovary* stellate-hairy; style 0.4–0.5 mm long. *Fruits* c. 2 mm long; seeds 1.2–1.3 mm long.

Distribution. Endemic to W.A. in the vicinity of Shark Bay, in shrub-steppe communities on sand.

Phenology. Flowers and fruits Aug.–Sept.

Note. This species and *St. patens* are the only taxa of *Stenanthemum* with spinescent branches. *Stenanthemum divaricatum* is closely related to *St. emarginatum* Rye, which differs in the more acute apical lobes of the leaves and a much denser indumentum on the lower surface.

Typification. The type specimens from Murchison River were collected by Augustus Oldfield. He collected in the service of Mueller (George 2009); the main set of specimens is preserved at MEL, with many duplicates in K and other institutions. The lectotype is the best preserved specimen, it contains several flowering branches, which display the typical spinescent branches.

Selected specimens examined

WESTERN AUSTRALIA. Quoin Bluff, Dorre Island, Aug. 1977, *A.S. Weston 10609* (PERTH); 6 miles [9.7 km] N of Quobba Homestead, Sep. 1970, *A.S. George 10154* (CANB, PERTH); Herald Bay, Dirk Hartog Island, Sep. 1972, *A.S. George 11501* (CANB, PERTH).

4. *Stenanthemum humile* Benth.

Fl. Austral. 1: 436 (1863). — *Cryptandra humilis* (Benth.) F.Muell., *Syst. Census Austral. Pl.* 61 (1882). — *Solenandra humilis* (Benth.) Kuntze, *Revis. Gen. Pl.* 1: 121 (1891). — **Type citation:** "Between Moore and Murchison rivers, *Drummond, n. 91* (the same number as *Spyridium polycephalum*, but probably from a different set)." — **Lectotype (here designated):** Between Moore & Murchison Rivers, 1853, *J. Drummond 91* (K000732089 ex Herb. Hooker, photo seen). **Isolectotypes:** Interior North of Swan River, between Moore & Murchison Rivers, 1850–51, *J. Drummond 91 (4th coll.)* (NY00415074, photo seen); Australie, *J. Drummond 91* (P04448396, ex Herb. Drake, photo seen); Between Moore & Murchison Rivers, 1854, *J. Drummond 91* (PERTH01599348 ex BM). **Possible isolectotype:** Swan River, *J. Drummond 91 (3rd coll.)* (LD1025262 *n.v.*, det. B.L. Rye).

Illustrations: B.J. Grieve, *How to Know W. Austral. Wildfl.* (2nd edn) 2: 594 (1998).

Fig. 2. *Stenanthemum leucophractum*, the type species of the genus. **A** Plant flowering in Cox Scrub Conservation Park (near Adelaide, S.A.); **B** fruiting plant growing in the Big Desert (Vic.); **C** close up of flowering branches, Wanilla Settlement Reserve (Eyre Peninsula, S.A.); **D, E** flower-heads, surrounded by white felty floral leaves, from Cox Scrub (D) and Wanilla (E). — A, D *J. Kellermann 655 & F. Nge* (AD), B *JK 934 & FN* (AD), C *JK 747 & FN* (AD), E *JK 743 & FN* (AD). Photos by J. Kellermann.

Low, erect *shrub* to 20 cm high with white-woolly young stems, lower leaf surfaces and flowers. *Leaves*: stipules ovate or rectangular, 4–6 mm long, almost fully connate, densely sheathing the stems; petiole 1.5–3.5 mm long; lamina linear or (occasionally) narrowly obovate to narrowly elliptic, (3–) 6–10 (–11) mm long, 1–2 (–4) mm wide, narrowly cuneate at base, with strongly revolute margins, apex obtuse, scabrid above. *Inflorescences* 1–1.5 cm wide, with up to 50 flowers. *Flowers* white to cream; free hypanthium tube 2.5–5 mm long, 0.8–1.5 mm diameter, moderately woolly. *Sepals* 0.7–1 mm long, densely woolly outside, inside with a red spot. *Petals* 0.5–0.6 mm long. *Disc* apparently absent. *Ovary* roof glabrous; style 3.2–5 mm long. *Fruits* 2–2.4 mm long; seeds 1.2–1.4 mm long. **Fig. 1.**

Distribution. Endemic to south-western W.A. between Three Springs and Regans Ford with an outlier near Perth, in low heath, shrubland or open woodland, usually on white sand over laterite.

Phenology. Flowers and fruits Aug.–Nov.

Note. This species is closely related to *St. pumilum*, with which it shares the prominently woolly sepals and less hairy floral tubes, but most obviously differs by its linear leaves. *Stenanthemum yorkense* Rye is also similar, but differs in its more open habit, stipules with broader closer acuminate points, larger leaves with the bright green upper surface opening fully, and longer flowers.

Typification. Bentham (1863) described the species from a sheet at K, designated here as the lectotype. As stated in the protologue, the specimen label does not mention which of Drummond's collections it belongs to. Duplicates of the Drummond collection are in several herbaria, but the dates are different on each of the specimens seen. The specimens in LD and NY also indicate that they are from Drummond's 3rd and 4th collection, respectively; these collection trips were undertaken in 1844/45 and 1847 (Barker 2004). However, these years are not mentioned on any of the specimens examined; the dates on the specimens are most likely when the specimens were received by the institutions.

Selected specimens examined

WESTERN AUSTRALIA. 7 km S of Regans Ford, 23 Sep. 1966, *E.M. Bennett 1315* (PERTH); 16 km SW of Three Springs on road to Eneabba, 30 Sep. 1966, *E.M. Bennett*

1414 (PERTH); Hi Vallee Farm of Don & Joy Williams, on 4WD track in native bushland, 8 Sep. 2001, *J. Kellermann 195* (AD, BAA, PERTH); Watheroo Natl Park, W of Watheroo, 4 Oct. 1971, *R.D. Royce 9582* (PERTH); Pioneer Park, Forrestfield, 19 Sep. 2010, *K.R. Thiele 4055* (PERTH).

5. *Stenanthemum leucophractum* (Schltdl.) Reissek

Linnaea 29: 295 (1858). — *Cryptandra leucophracta* Schltdl., *Linnaea* 20: 640–642 (1847). — *Spyridium leucophractum* (Schltdl.) F.Muell., *Fragm.* 3: 77 (1862). — *Solenandra leucophracta* (Schltdl.) Kuntze, *Revis. Gen. Pl.* 1: 121 (1891), as "*leucophractum*". — *Trymalium leucophractum* F.Muell. ex Reissek, *Linnaea* 29: 295 (1858), *nom. inval.*, *pro syn.* — **Type citation:** "Auf der Sandplaine genannten sandig-kalkigen Gegend, Januar". — **Lectotype (here designated):** Sandplaine, [*H.H. Behr s.n.* {157}] (HAL0098601, photo seen). **Isolectotype:** *H.H. Behr s.n.* {157} (HAL0107594, photo seen).

Illustrations: W.R. Barker *et al.*, *J. Adelaide Bot. Gard.* 11: 70, fig. 2 (1988), as *Cryptandra leucophracta*; G.R.M. Dashorst & Jessop, *Pl. Adelaide Plains & Hills* 101: pl. 43, fig. 2 (1990); G.J. Harden, *Fl. New S. Wales* 1: 370 (1990), as *C. leucophracta*; N.G. Walsh & T.J. Entwisle, *Fl. Victoria* 4: 113, fig. 19I (1999).

Small, spreading *shrub* to 0.4 m (rarely to 1 m) high, with rusty or greyish densely villous or pubescent young stems. *Leaves*: stipules narrowly triangular, 2–4 mm long, connate to less than half of their length; petiole 0.5–2 mm long; lamina obovate to broadly obovate, 3–6 (–10) mm long, 2–6 mm wide, cuneate at base, flat or folded, apex obtuse and recurved-apiculate, rarely acute, glabrous and tuberculate above, grey or rusty and appressed-villous beneath. *Inflorescences* to 1 cm wide, with 15–40 flowers, subtended by whitish floral leaves. *Flowers* white or greyish woolly-hirsute; free hypanthium tube 2.5–3.5 mm long, 0.8–1 mm diameter. *Sepals* 1–1.2 mm long. *Petals* 0.5–0.6 mm long, distinctly clawed. *Disc* apparently absent. *Ovary* roof glabrous; style 3.5–4.0 mm long. *Fruits* 2.0–3.0 mm long; seeds 1.5–1.8 mm long. (Description first published in Thiele 2007.) **Fig. 2.**

Distribution. Widespread in mallee scrub from Eyre Peninsula and Kangaroo Island, South Australia (S.A.), to north-western Victoria (Vic.), with an outlying population between Mount Hope and Ardlethan, New South Wales.

Phenology. Flowers and fruits Sep.–Dec.

Common name. White stenanthemum (FNCV 1923), white cryptandra (Ewart 1931), rusty poison (Canning & Jessop 1986).

Note. The species is similar to *St. arens* K.R.Thiele, which differs in having densely stellate hairy stem leaves and flowers with a shorter hypanthium tube (0.9–1.2 mm long).

Typification. This species was described from specimens collected by Behr in the Barossa Valley, South Australia, around 1845. Behr presented all his specimens to Schlechtendal in Halle, who enumerated and described among them three species of Rhamnaceae (see also Kellermann 2020).

There are two sheets of *Stenanthemum leucophractum* in HAL (Heuchert *et al.* 2017), both with ample material. The sheet with the label mentioning the collection locality "Sandplaine" (sandy plain) is selected as the lectotype.

Selected specimens examined

SOUTH AUSTRALIA. Vivonne Bay, Kangaroo Island, 9 Oct. 1982, *W.R. Barker 4543* (AD, CANB); Site 31 near Springton, c. 4.3 km W of Springton, 3 Oct. 1984, *E.N.S. Jackson 5526* (AD, MEL, NSW); Rocky Bend Flora Reserve, 12 Sep. 2019, *J. Kellermann 862 & E. Biffin* (AD, MEL).

VICTORIA. Pink Lakes State Park, 20 Oct. 1986, *E.A. Chesterfield 1828* (MEL); Little Desert, McDonald Hwy, c. 8 km from Nhill Rd turnoff, 16 Aug. 2001, *J. Kellermann 147, N.G. Walsh & I.R. Thompson* (AD, B, NY); Big Desert, Murrayville Nhill Rd, 13 km South of Murray Hwy, 16 Oct. 2019, *J. Kellermann 917 & F. Nge* (AD, MEL).

NEW SOUTH WALES. 4 km W of Kamarah, 13 Nov. 1975, *M.D. Crisp 1523* (AD, BISH, CBG at CANB, MEL, NSW); 20 km E of Goolgowi, 16 Dec. 1960, *R. Filson 3517* (AD, CANB, MEL).

6. *Stenanthemum notiale* subsp. *chamelum* Rye

Nuytsia 10: 294 (1995). — *Cryptandra tridentata* var. [β] *tomentosa* Reissek in Lehm., *Pl. Preiss.* 2: 289 (1848). — **Type citation:** "In arenosis inter fructices densos ad latus meridionale montis „Eliza" (Perth). 25 Sept. 1839. Herb. Preiss. No. 1216." — **Lectotype:** In arenosis inter fructices densos ad latus meridionale montis „Eliza„ (Perth), 25 Sep. 1839, *L. Preiss 1216* (LD1067791, annotated by Reissek, photo seen), *fide* Rye, *Nuytsia* 10: 294 (1995), as "type". **Isolectotypes:** MEL2099097 (ex Herb. Sonder), MEL2099098 (ex Herb. Sonder), MO-2176043 (photo seen), P06786200 (ex Herb. Steudel, photo seen), S10-12730 (photo seen), ?W (*n.v.*).

Illustration: B.L. Rye, *Nuytsia* 10: 288 (1995), fig. 9P–S; B.J. Grieve, *How to Know W. Austral. Wildfl.* (2nd edn) 2: 596 (1998); E.M. Bennett, *Perth Pl.* 153, fig. 10–12 (2005), photographs.

Prostrate *shrub* to 20 cm high, with greyish or rusty, sparsely to (rarely) densely stellate-pubescent young stems. *Leaves*: stipules ovate to broadly triangular, 0.8–2 mm long, connate for about a third to half of their length; petiole 0.5–2.0 mm long; lamina obovate to broadly obovate, 6–12 mm long, (3–) 5–7 mm wide, cuneate at base, the margins ± recurved, apex tridentate or emarginate, glabrous and scabrous above, pubescent to villous beneath with grey or rusty, simple and/or stellate hairs. *Inflorescences* to 0.8 cm wide, with 10–20 flowers. *Flowers* densely greyish-pubescent or villous

with simple and/or stellate hairs; free hypanthium tube to 0.4 mm long, 0.6–1.2 mm diameter. *Sepals* 0.8–1.2 mm long. *Petals* 0.5–0.7 mm long, distinctly clawed. *Disc* conspicuous. *Ovary* roof stellate-hairy; style 0.6–0.7 mm long. *Fruits* 2–2.2 mm long; seeds 1.1–1.5 mm long.

Distribution. Endemic to south-western W.A., on the coastal plain between Lancelin and Perth, in heath and shrubland usually over limestone.

Phenology. Flowers and fruits throughout the year.

Note. *Stenanthemum notiale* Rye is closely related to *St. intricatum* Rye, which differs in its smaller leaves with shorter petioles and different indumentum on the upper surface of the leaves. The sepals and hypanthium tube of *St. intricatum* are of a similar length, in contrast to the two subspecies of *St. notiale*, which have a very short hypanthium tube.

The typical subspecies differs from subsp. *chamelum* in its more erect habit and leaves with simple and/or stellate hairs on the upper surface. The leaves of subsp. *chamelum* always have 1–3 teeth on either side of the apex, whereas subsp. *notiale* has a mixture of entire and 3-toothed leaves.

Typification. In the protologue of *Stenanthemum notiale* subsp. *chamelum*, Rye (1995) inadvertently lectotypified by listing one specimen of *Cryptandra tridentata* var. *tomentosa* from LD as "type". Preiss's top set of specimens is held at LD; duplicates of *Preiss 1216* are in several herbaria, the isolectotype at P is from Ernst Gottlieb von Steudel's herbarium.

Selected specimens examined

WESTERN AUSTRALIA. Between Lancelin and Guilderton, 1 Dec. 1974, *R. Pullen 9786* (CANB, PERTH); 5 km W of Moore River along Old Bennie's Rd, Moore River State Forest, 5 Sep. 1978, *J. Dodd 18* (PERTH); Yanchep, 21 May 1963, *A.S. George 4379* (PERTH); Nilgen Nature Reserve, E of Lancelin, by the road to Mimegarra, 27 Sep. 1991, *W. Greuter 22261* (B, PERTH).

7. *Stenanthemum pimeleoides* (Hook.f.) Benth.

Fl. Austral. 1: 436 (1863), as "*pimelioides*". — *Cryptandra pimeleoides* Hook.f., *Fl. Tasman.* 1: 75, t. 12A (1855). — *Solenandra pimeleoides* (Hook. f.) Kuntze, *Revis. Gen. Pl.* 1: 121 (1891), as "*pimelodes*". — **Type citation:** "East coast, Kelvedon, at Great Swan Port, Backhouse. Spring Bay, Gunn." — **Lectotype (here designated):** Spring Bay, East Coast, 1 Apr. 1840, *R.C. Gunn 1041/1842* (K001096731 & K001096732, on one sheet, ex Herb Hooker). **Isolectotypes:** BM000050767; NSW515587. **Residual syntype:** Kelvedon, Gt Swan Port, East Coast, [*Backhouse s.n.*] (K001096733, ex Herb. Hooker).

Illustrations: J.D. Hooker, *Fl. Tasman.* 1: pl. 12 (1855); M. Stones & W. Curtis, *Endem. Fl. Tasman.* 2: opp. 72, fig. 72 (1969); M. Cameron, *Guide Fl. Pl. Tasman.* 87, fig. 206 (1981), photograph.

Prostrate, small *shrub* with greyish- or rusty-villous young stems. *Leaves*: stipules narrowly triangular, 2.5–7 mm long, connate behind the petiole, often overlapping and sheathing the stems; petiole 1–2.5 mm long; lamina obovate to almost flabellate, 2–7 mm long, 2–6 mm wide, cuneate at base, with narrowly recurved margins, apex obtuse, glabrous and minutely tuberculate above, appressed-sericeous to villous below. *Inflorescences* to 1 cm wide, with 10–50 flowers, subtended by a few white floral leaves. *Flowers* densely white- or greyish-woolly; free hypanthium tube 2.4–2.7 mm long, 0.8–1.2 mm diameter, glabrous at base. *Sepals* 0.8–1.2 mm long. *Petals* 0.6–0.7 mm long, distinctly clawed. *Disc* apparently absent. *Ovary* roof glabrous; style (2.2–) 3.5–3.8 mm long. *Fruits* 2–2.5 mm long; seeds 1.2–1.4 mm long. (Description first published in Thiele 2007.) **Fig. 3.**

Distribution. Endemic to Tasmania, on the east coast between Orford and Bicheno, in heathland and forest (see also TPP 2009).

Phenology. Flowers Dec.–Feb.; fruits all year.

Fig. 3. *Stenanthemum pimeleoides*, illustrated from a specimen collected near Swansea (Tas.). **A** Habit ×0.6; **B** inflorescence with felty floral leaves ×3.7; **C** flower ×10; **D** connate pair of stipules with petiole ×10. — *A.M. Buchanan 4796* (MEL). Line drawing by Anita Barley.

Common name. Propeller plant, spreading stenanthemum (Wapstra *et al.* 2010).

Note. The species shares with *Stenanthemum humile* and *St. pumilum* stipules that sheath the stem, but *St. pimeleoides* has broader (obovate) leaves and prominent floral leaves, similar to *St. leucophractum*.

Typification. The lectotype has two barcodes, but it is unclear to which of the five branches these belong. The whole sheet is here selected as the lectotype as all branches seem to be part of the same gathering by Gunn. A pencil drawing is also attached to the sheet, which was the basis of the plate in Hooker (1855). Duplicates of this collection are at BM and NSW. A sheet at K with three branches is a residual syntype, and even though no collector is written on the label, it must be the Backhouse specimen mentioned in the protologue.

Selected specimens examined
TASMANIA. Near Freestone Hill, 20 km N of Swansea, 11 Dec. 1984, *A.M. Buchanan 4796* (BRI, HO, K, MEL, NT); Coles Bay Rd, Apsley Bridge, 1 km ESE of Llandaff, 25 Jan. 1989, *F.E. Davies 1238* (AD, CBG at CANB, HO, MEL); 7 miles [11.3 km] from Tasman Hwy along Lake Leake turnoff, 19 Nov. 1952, *R. Melville 2525, J. Willis, H. Barber & D. Paton* (K, MEL, NSW); Tom Gibson Reserve, approx. 700 m NW of main entrance on Bartons Rd, 16 Nov. 2016, *M.F. de Salas 1766* (HO).

8. *Stenanthemum pomaderroides* (Reissek) Reissek

Linnaea 29: 295 (1858). — *Cryptandra pomaderroides* Reissek in Endl. & Fenzl, *Nov. Stirp. Dec.* 4: 29 (1839). — *Solenandra pomaderroides* (Reissek) Kuntze, *Revis. Gen. Pl.* 1: 121 (1891), as "*pommaderodes*". — **Type citation:** "*In Novae-Hollandiae austro-occidentalis interioribus legit* cl. Roë." — **Syntype:** Interior of Western Australia, *J.S. Roe s.n.* (W *n.v.*, *fide* B.L. Rye, pers. comm.).

Illustrations: B.J. Grieve, *How to Know W. Austral. Wildfl.* (2nd edn) 2: 598 (1998).

Erect *shrub* to 1.5 m high with densely rusty-pubescent young stems. *Leaves*: stipules ovate or triangular, 3–6 mm long, free; petiole 2–4 mm long; lamina obovate, (5–) 12–18 (–20) mm long, (3–) 5–8 (–10) mm wide, flat, cuneate at base, incurved or folded, apex acute to emarginate and recurved-apiculate, muricate, scabrous or tuberculate, glabrous or stellate-hairy above, greyish-villous below usually with rusty hairs along the veins. *Inflorescences* to 1.5 cm wide, with 10–30 flowers, often subtended by white floral leaves. *Flowers* creamy-pubescent; free hypanthium tube 2.2–4.5 mm long, 1–1.5 mm diameter. *Sepals* 1.1–1.4 mm long. *Petals* 0.7–0.8 mm long, distinctly clawed. *Disc* inconspicuous. *Ovary* roof glabrous; style 3–5 mm long. *Fruits* 2.8–3.2 mm long; seeds 1.6–2 mm long.

Distribution. Endemic to south-western W.A., in shrubland and woodland, both on sandy soils and in rocky places, between Kalbarri and Wyalkatchem.

Phenology. Flowers and fruits Aug.–Nov.

Note. Plants from the vicinity of Kalbarri National Park differ from typical plants in having somewhat narrower leaves that are finely stellate-hairy above, rather than glabrous and tuberculate. They may prove to be a distinct taxon. The species is close to *Stenanthemum reisekii* and *St. poicilum* Rye, which have smaller leaves and inflorescences, and connate stipules.

Typification. The taxon was described from a collection by John Septimus Roe, who undertook several expeditions through Western Australia. Barbara Rye (pers. comm.) examined the type of *Cryptandra pomaderroides* from W in preparation for Rye (1995): the specimen corresponds with the southern form of the species. It is unclear if duplicates are at other herbaria, such as K, as we have not been able to trace any others. However, as we have not seen this specimen, we refrain from designating a lectotype.

Selected specimens examined
WESTERN AUSTRALIA. Manmanning, 23 Oct. 1992, *L.A. Craven 8890 & F.A. Zich* (AD, BRI, CANB, MEL, PERTH); Wilding Rd NW of Wongan Hills, 16 Sep. 2001, *J. Kellermann 286* (AD, BAA, MEL); Kalbarri Natl Park, "The Loop" at Murchison River Gorge, 28 Sep. 1989, *B. Nordenstam & A.A. Anderberg 121* (MEL, NSW, PERTH); 9.2 miles [14.8 km] W of Bindi Bindi on Bindi Bindi–Ballidu Rd, 28 Sep. 1971, *S. Paust 1024* (PERTH); 0.6 km S along Billeroo Rd from Carnamah–Bunjil Rd, 27 Aug. 2011, *K.R. Thiele 4195* (PERTH).

9. *Stenanthemum pumilum* (F.Muell.) Diels

in Diels & E.Pritzel, *Bot. Jahrb. Syst.* 35: 356 (1904). — *Spyridium pumilum* F.Muell., *Fragm.* 9: 137 (1875). — *Cryptandra pumila* (F.Muell.) F.Muell., *Syst. Census Austral. Pl.* 61 (1882). — *Stenanthemum leucocephalum* Domin, *Věstn. Král. Ceské Společn. Nauk, Tř. Mat.-Přír.* 2: 64 (1923), *nom. illeg.*, *pro syn.* — *Stenanthemum pumilum* subsp. *pumilum*: Rye, *Nuytsia* 16: 378 (2007) — **Type citation:** "In cacuminibus petraeis montium Stirling's Range, altitudine 3000'. F.M." — **Lectotype (here designated):** North of Stirling's Range / High rocky part of Stirlings Range, Oct. 1867, *F. Mueller s.n.* (MEL2290284, annotated as "holotype"). **Isolectotype:** Stirling Range, *F. Mueller s.n.* (K000732088, "Com. 12/1884", photo seen).

Illustration: B.L. Rye, *Nuytsia* 10: 301, fig. 12G–H (1995); B.J. Grieve, *How to Know W. Austral. Wildfl.* (2nd edn) 2: 597 (1998).

Compact *shrub* to 10 cm high, but mostly 2–5 cm high, with silvery or rusty, simply pubescent or pilose young stems. *Leaves*: stipules broadly triangular or ovate, 2.5–3.5 mm long, connate for more than half of

their length, ± sheathing the stems; petiole 1–1.5 mm long; lamina narrowly ovate to broadly obovate, 4–7 mm long, 1.4–2.5 mm wide, cuneate at base, with ± flat margins, conduplicate at first then opening at centre and sometimes at base but with the apex usually remaining closed, densely appressed-pilose below, minutely hispid above. *Inflorescences* 6–10 mm diam., with 10–30 flowers. *Flowers* white-woolly with long, crisped hairs; free hypanthium tube c. 1.5 mm long, 1–1.4 mm diameter, moderately woolly with an almost glabrous base. *Sepals* 1–1.2 mm long, densely woolly. *Petals* 0.5–0.6 mm long. *Disc* apparently absent. *Ovary* roof glabrous; style 1.6–2.2 mm long. *Fruits* (1.6–) 1.8–2.3 mm long; seeds c. 1.4–1.5 mm long.

Distribution. Endemic to the eastern Stirling Range in the south-western Botanical Province of W.A. The typical subspecies grows in low heath on gravel, with one record in rocky sandy soil in *Eucalyptus* shrubland and one from massive laterite.

Phenology. Flowers and fruits Sep.–Oct.

Note. The species is related to *Stenanthemum humile*, with which it shares prominently woolly sepals contrasting with less hairy floral tubes. It is also very close to *St. yorkense*, which differs in its more open habit, larger leaves and longer flowers.

Typification. The species was described by Mueller (1875) from collections that he made in W.A. Two type sheets of this species are known: the one from MEL contains three complete plants with labels written by Mueller; the sheet in K was forwarded by Mueller in 1884 and is a duplicate of the MEL collection.

Selected specimens examined
WESTERN AUSTRALIA. Warrangup Hill, Stirling Range, Oct. 1928, *C.A. Gardner 2200* (PERTH); Stirling Range Scenic Drive, NE of Mondurup, Sep. 1971, *A.S. George 10918* (PERTH); Chester Pass, East Stirlings, 16 Sep. 1963, *E. Wittwer 212* (PERTH).

10. *Stenanthemum tridentatum* (Steud.) Reissek

Linnaea 29: 295 (1858). — *Cryptandra tridentata* Steud. in Lehm., *Pl. Preiss.* 1: 186 (1845). — *Spyridium tridentatum* (Steud.) Benth., *Fl. Austral.* 1: 427 (1863); *Cryptandra tridentata* var. *pubescens* Reissek in Lehm., *Pl. Preiss.* 2: 288 (1848), *nom. inval.* — **Type citation:** "In N. Holl. occ. austr. Herb. Preiss. No. 2421." — **Lectotype:** In Australia occidentali, *L. Preiss 2421* (LD1067820, photo seen), *fide* Rye, *Nuytsia* 10: 304 (1995), as "type". **Isolectotypes:** MEL268670, P06786195 (ex Herb. Steudel, photo seen).

Illustrations: B.L. Rye, *Nuytsia* 10: 292, fig. 10F–J; B.J.Grieve, *How to Know W. Austral. Wildfl.* (2nd edn) 2: 594 (1998).

Spreading, intricate *shrub* to 35 cm high with sparsely stellate-hairy young stems. *Leaves*: stipules broadly triangular or rectangular, 1–1.5 mm long, connate for much of their length; petiole 0.5–1 mm long; lamina obovate to flabellate, 2–5 mm long, 2–3 mm wide, narrowly cuneate at base, flat or folded, emarginate, apex tridentate or variably toothed, densely stellate-hairy when young, finally smooth and glabrous. *Inflorescences* with 1–3 flowers. *Flowers* densely stellate-hairy; hypanthium without a free tube, c. 1 mm diameter. *Sepals* 0.9–1.1 mm long. *Petals* 0.5–0.6 mm long, distinctly clawed. *Disc* conspicuous. *Ovary* roof glabrous; style 0.5–0.9 mm long. *Fruits* ± glabrous, 1.8–2.2 mm long; seeds 1.4–1.6 mm long.

Distribution. Endemic to south-western W.A. between Gunyidi and Tambellup, in woodlands and shrublands mostly on sandy soil.

Phenology. Flowers Aug.; fruits Aug.–Oct.

Note. Many other species with tridentate or toothed leaf apices have been misidentified as this species. Taxa most closely related to *Stenanthemum tridentatum* are *St. divaricatum* and *St. emarginatum*. All three species share a sparsely hairy lower part of the hypanthium tube, but *St. divaricatum* and *St. emarginatum* tend to have more papillose young stems, shorter hairs on the ovary summit and paler mottled seeds. Other related species include *St. intricatum* and *St. notiale*.

Typification. The name was inadvertently lectotypified by Rye (1995). The isolectotype in P is from Steudel's own herbarium.

Selected specimens examined
WESTERN AUSTRALIA. Near Gunyidi, 18 Sep. 1978, *J.W. Green 5502* (PERTH); Between Katanning and Tambellup, c. 7 km S of Broomehill, 31 July 1959, *Hj. Eichler 15909* (AD); West River, 26 Oct. 1961, *C.A. Gardner 13770* (PERTH); Jingaring Nature Reserve, 30 km NW from Pingelly, 22 Sep. 2001, *J. Kellermann 321* (AD); 100 miles [160 km] N of Perth on Geraldton Hwy, 17 July 1953, *R. Melville 4099 & J. Calaby* (K, MEL, NSW).

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The importance of the 'h' – Parahomonymy in *Trymalium* (Rhamnaceae: Pomaderreae)

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Abstract: The history of the species names *Trymalium spatulatum* (Labill.) G.Don from Western Australia and *T. spathulatum* F.Muell., currently known as *Spyridium spathulatum* (F.Muell.) Benth., from South Australia is discussed. Even though the species epithets differ by an 'h', it is concluded that the names are so similar that they are likely to be confused and should be treated as homonyms. The name *T. daphnoides* Reissek is available for the latter species and the new combination *S. daphnoides* (Reissek) Kellermann is published, placing the taxon into the correct genus. Lectotypes are chosen for both species.

Keywords: Rhamnaceae, Pomaderreae, nomenclature, near homonym, parahomonym, illegitimate names, Australia

Introduction

During research for the *Flora of Australia* treatment of Rhamnaceae (Thiele *et al.*, in prep.), the following two species names were found to be in conflict and in need of resolution:

- ***Trymalium spatulatum*** (Labill.) G.Don was one of the first species of Rhamnaceae described and illustrated from Australia (Fig. 1). It was collected by Labillardière during the d'Entrecasteaux expedition and published as *Ceanothus spatulatus* Labill. in his *Novae Hollandiae plantarum specimen* (Labillardière 1805). Until recently, it was accepted that Ostenfeld (1921) was the first to transfer *Ceanothus spatulatus* to *Trymalium* Fenzl. However, during literature searches it was discovered that the new combination had already been published by Don (1839), i.e. the publication date of *T. spatulatum* was more than 90 years earlier. Recent molecular work supports its placement in *Trymalium* (F. Nge, pers. comm.).
- ***Trymalium spathulatum*** F.Muell. is the basionym of the species name for a well-known South Australian shrub (Fig. 2), currently known as *Spyridium spathulatum* (F.Muell.) Benth. It was named by Mueller (1855) from specimens collected in the Mt Lofty Ranges and on Kangaroo Island. Bentham (1863) transferred the taxon to *Spyridium* Fenzl. Molecular data have confirmed its position in that genus (C. Clowes, pers. comm.).

Rye (1996) and Kellermann *et al.* (2008) stated that the use of the name *Trymalium spatulatum* (Labill.) Ostenf. for the Western Australian taxon was in doubt, as *T. spathulatum* F.Muell. pre-dates it and they are near-homonyms. The discovery of the combination by Don (1839) reverses the chronology: the name of the Western Australian taxon has now been 'saved', but the name for the South Australian species, *Spyridium spathulatum*, seems to be illegitimate, as its basionym, *T. spathulatum* F.Muell., was published later than *T. spatulatum* (Labill.) G.Don.

The confusion

The only difference between these two names is the presence of an 'h' in the species epithet for the South Australian taxon. In both instances the epithets refer to the shape of the leaf in the species, i.e. having "a broad rounded upper part tapering gradually downwards into a stalk" (Stearn 1983: 514).

Both *spatulatum* and *spathulatum*[1] ('spatulate' and 'spathulate') have been used interchangeably by botanists. Botanical glossaries and dictionaries also treat both terms as equivalent (e.g. Craig 1849; Jackson 1900; Stearn 1983; McCusker 1999; Short & George 2013), however it seems that in the late 18th and early 19th century, the spelling *spatulatum* was preferred in French and English books (e.g. Martyn 1793; Candolle

1 In the discussion the word is only used in the neuter gender, even though it sometimes refers to the use of the epithet in all three genders, as well, i.e. *spat(h)ulatus*, *-a*, *-um*.

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Fig. 1. *Ceanothus spatulatus* Labill., plate 84 in Labillardière's *Novae Hollandiae plantarum specimen*, drawn by Pierre-Antoine Poiteau; current name: *Trymalium spatulatum* (Labill.) G.Don. — Image reproduced from the Biodiversity Heritage Library.

1813; Lloyd 1826), with *spathulatum* more prevalent in the German literature (e.g. Illiger 1800; Bischoff 1839).

A search in IPNI (2020) resulted in about ten times as many names with the spelling *spathulatum* than *spatulatum*; in the Australian context the ratio was about six to one (APNI 2020). When quoting these names, botanists also frequently made errors, e.g. inserting an 'h' into *spatulatum*.

In the *Trymalium* names considered here, that of the Western Australian taxon (correctly *T. spatulatum*) was frequently spelt as "*T. spathulatum*", but I was not able to find a case where the name of the South Australian species was spelt without the 'h'. The basionym *Ceanothus spatulatus* was spelt incorrectly by Dietrich (1816), Steudel (1821), Sprengel (1825), Brongniart (1826), Fenzl (1837), Koch & Fintelmann (1859) and Bentham (1863). *Trymalium spatulatum* was spelt with an added 'h' by, among others, Ostenfeld (1921), Gardner (1931), Suessenguth (1953) and Green (1981), and this was the usual spelling of the name until Rye (1995, 1996) reviewed *Trymalium* in Western Australia. Despite this, the incorrect spelling *spathulatum* was still used in some recent works (e.g. Mackensen *et al.* 2003; Attiwill & Wilson 2006; Sweedman & Merritt 2006).

There are many other instances of taxon names where spelling of the epithets *spatulatum* or *spathulatum* has been confused:

- The name of the fern *Elaphoglossum spatulatum* (Bory) T.Moore, based on *Acrostichum spatulatum* Bory, was spelt by Moore (1857) with an 'h' when transferring the species to *Elaphoglossum* Schott ex J.Sm., and the incorrect spelling was and is still used in many publications (e.g. Roux 2009; Klopper *et al.* 2010).
- The name *Embothrium spathulatum* Cav., a synonym of *Telopea speciosissima* (Sm.) R.Br., was originally published with both spellings: in the protologue of Cavanilles (1798: 60) the main entry gives the epithet with the 'h', but on the illustration, plate 388, which was issued simultaneously, it appears without the 'h'.
- The basionym of the name of the fungus *Hyphodontia spathulata* (Schrad.) Parmasto was originally published as *Hydnum spatulatum* Schrad. (Schrader 1794), but the spelling of the epithet was later sanctioned by Fries (1821: 423) as *spathulatum*, and is as such conserved with that spelling (Art. F.3.2; May *et al.* 2019).
- The species epithet of the Tasmanian *Senecio spathulatus* Rich. (Richard 1834) was sometimes also mis-spelt as *spatulatus* (e.g. Mueller 1875, 1882). A similar situation as described here for *Trymalium* also exists in *Senecio*: Jessen (1879) published the name Senecio *spatulatus* Jess. for a species from the European Alps.
- Some other examples of names from the Australian flora where these spellings have been used interchangeably are listed below (see APNI 2020; the spelling cited is as originally published): *Acacia spathulata* F.Muell. ex Benth. (a synonym of *A. spathulifolia* Maslin), *Baeckea spatulata* (Turcz.) F.Muell., *Dodonaea viscosa* var. *spatulata* (Sm.) Benth., *Drosera spatulata* Labill., *Myosotis spathulata* G.Forst., *Pimelea spatulata* Labill., *Ptilotus spathulatus* (R.Br.) Poir., *Scholtzia spatulata* (Turcz.) Benth. and *Staurogyne spatulata* (Blume) Koord.

Taxonomic history

Ceanothus spatulatus was collected by Labillardière near Esperance Bay, Western Australia, in Dec. 1792 (Stafleu 1967) and described by him in 1805; type specimens of the species are present in FI, where Labillardière's herbarium is preserved, as well as in several other institutions. Fenzl (1837) established the genus *Trymalium* and transferred *C. spatulatus* there. To honour the discoverer of the species, he renamed it *T. billardierei* Fenzl — but, as Labillardière's epithet was available in *Trymalium*, Fenzl created a nomenclaturally superfluous and illegitimate name (Art. 52; Turland *et al.* 2018), which was nevertheless used by botanists until the early 20th century.

George Don edited and updated the third edition of Sweet's well-known *Hortus Britannicus* (Don 1839) after the original author's death. He published the combination *Trymalium spatulatum* (Labill.) G.Don therein, attributing the name to "Hug.", i.e. a reference to Fenzl's (1837) treatment in *Enumeratio Plantarum* […] *Hügel*. However, as stated above, Fenzl did not publish the combination there, but named the species *T. billardierei*. The correct name for the species was rarely used; it was referenced in a few other publications and usually authorship was incorrectly attributed to "Sweet" (e.g. Steudel 1841; Dammer 1895). Jacques (1844), writing an article about *Trymalium* species in cultivation, used *T. spatulatum* for the Western Australian species; since he also refers to "Hugel" as the author of the name, he presumably used Don (1839) as the basis of his article.

Ostenfeld (1921: 85) realised that "[A]ccording to the rules of nomenclature it is necessary to take up Labillardière's earlier species name for this well-known shrub", i.e. that Fenzl (1837) did not use the correct epithet when transferring the species to *Trymalium*. As Ostenfeld was not aware of the combination by Don (1839), he republished the new combination and the name with that author citation, i.e. *T. spatulatum* (Labill.) Ostenf., has been in use until now; but it is a later isonym with no nomenclatural standing (Art. 6.3 Note 2). When republishing this name, Ostenfeld made the same mistake as many other botanists and inserted an 'h' into the epithet.

Mueller (1855) described ***Trymalium spathulatum*** from plants collected in the Mt Lofty Ranges and Kangaroo Island, South Australia; type material can be found in MEL and K. Reissek (1858) apparently realised a possible conflict of epithets and wanted to rectify this by publishing *T. daphnoides* Reissek as a replacement name for the South Australian *T. spathulatum* (Art. 6.11), citing "*T. spathulatum* […] F.Müll nec Labill." in synonymy. However, at the time, the name *T. billardierei* was in general use for the Western Australian species and other botanists did not take up Reissek's name; they possibly deemed it unnecessary, as the names of the two species were not in conflict.

Both species were over the years also assigned to *Cryptandra* Sm. or *Pomaderris* Labill., as the delimitation of the genera of Australian Rhamnaceae was not settled until recently (reviewed by Kellermann 2007).

Conclusion

As outlined above, the names *Trymalium spatulatum* (Labill.) G.Don and *T. spathulatum* F.Muell. should be treated as homonyms, as the two spellings of the epithets have been used interchangeably for more than 200 years. This is in accord with Art. 53.2 (Turland *et al.* 2018), which states that "[W]hen two or more names of genera or species based on different types are so similar that they are likely to be confused" (i.e. they are parahomonyms; Hawksworth 2010), "they are to be treated as homonyms". As explained above, there is no doubt that these epithets can easily be confused.[2] The problem is also not limited to *Trymalium*; there are many plant names with the epithets *spatulatum* or *spathulatum*, for which the spellings were and still are confused.

Hence the name of the South Australian species *Trymalium spathulatum* F.Muell. is to be treated as a later homonym of the Western Australian *T. spatulatum* (Labill.) G.Don and therefore illegitimate. The currently used name, *Spyridium spathulatum*, is not a new combination by Bentham (1863), due to the illegitimacy of *T. spathulatum* F.Muell., but is here treated as a replacement name, re-using the original epithet in *Spyridium* (Art. 58.1). This name, *S. spathulatum* F.Muell. ex Benth., would be the correct name of the species in that genus were it not for *T. daphnoides* Reissek having been published based on the same type in 1858 (Art. 6.11). This renders *S. spathulatum* F.Muell. ex Benth. nomenclaturally superfluous and illegitimate, as Bentham should have taken up the epithet *daphnoides* from the earliest legitimate name at species rank. All three names, *T. spathulatum*, *T. daphnoides* and *S. spathulatum*, are homotypic.

Since no legitimate name for the South Australian taxon is available in the genus *Spyridium*, the new combination *Spyridium daphnoides* (Reissek) Kellermann is published below.

Nomenclature

Trymalium spatulatum (Labill.) G.Don

Sweet's Hort. Brit. Ed. 3, 137 (1839); Jacq., *Rev. Hort. J. Jard. Amateurs* 6(2): 26 (1844). — *Ceanothus spatulatus* Labill., *Nov. Holl. Pl.* 1: 60, t. 84 (1805), as "*spatulata*". — *Pomaderris spatulata* (Labill.) G.Don in Loudon, *Hort. Brit.* 84 (May 1830). — *Pomaderris spatulata* (Labill.) Brongn. ex Sweet, *Hort. Brit. Ed. 2*, 113 (Oct.–Dec. 1830), isonym. — *Trymalium billardierei* Fenzl in Endl. *et al.*, *Enum. Pl.* 25 (1837), as "*Billardieri*", *nom. superfl. & illeg.* — *Cryptandra billardierei* F.Muell., *Syst. Census Austral. Pl.* 60 (1882), as "*Billardieri*", *nom. illeg.* — *Trymalium spatulatum* (Labill.) Ostenf., *Biol. Meddel. Kongel. Danske Vidensk. Selsk.* 3(2): 85 (1921), as "*spathulatum*", isonym. — **Type citation:** "in terrâ Van-Leuwin". **Lectotype (here designated):** Nova Hollandia et Terra van Diemen, *J.H.H. de Labiardière s.n.* (FI006702, ex. Herb. Labill., photo seen; Fototeca no. 835; old Herb. Webbianum accession no. 035602; with Labillardière's original manuscript description). **Isolectotypes:** Nova Hollandia, *J.H.H. de Labiardière s.n.* (B-W04713-000, ex. Herb. Willd., determined by Reissek, photo seen; FI006703, ex. Herb. Desf., Fototeca no. 835/A, old accession no. 035603, photo seen; G-DC; P06883568, ex Herb. Webbianum, photo seen; P06883569, ex Herb. Drake, photo seen; TCD0013850, donated by Bory in 1844, photo seen).

Trymalium billardierei var. [α] *dense-tomentosum* Fenzl in Endl. *et al.*, *Enum Pl.* 25 (1837), as "*dense-tomentosa*", *nom. inval.* (Art. 26.2; intended as type variety).

Distribution. Endemic to south-western Western Australia, near Mount Barren and between Esperance and Cape Arid, on near-coastal granite outcrops.

Common name. Spatulate-leaved trymalium (Don 1839).

Typification. The lectotype in FI has Labillardière's original manuscript descriptions attached to it and contains ample material. Duplicates can be found in several herbaria.

Note. Pfeiffer (1871–1875) designated this species as the type of the genus *Trymalium*.

Spyridium daphnoides (Reissek) Kellermann, ***comb. nov.***

Trymalium spathulatum F.Muell., *Defin Austral. Pl.* 42 (1855) & *Trans. Proc. Victorian Inst. Advancem. Sci.* 122 (1855), *nom. illeg.*, *non Trymalium spatulatum* (Labill.) G.Don in *Sweet's Hort. Brit. Ed. 3*, 137 (1839).

2 This was also confirmed by an informal vote of the *Committee for Vascular Plants* several years ago (R.K. Brummitt, *in litt.*, 26 Sep. 2007).

Fig. 2. *Spyridium daphnoides* (Reissek) Kellermann – formerly known as *S. spathulatum* (F.Muell.) Benth. – at Deep Creek Conservation Park, South Australia. **A** Plant growing in open coastal shrubland; **B** conflorescence made up of several dense flower-heads, each subtended by a white felty floral leaf; **C, D** close-up of inflorescences. — A, C *J. Kellermann 1001* (AD); B *JK 1002* (AD); D *JK 998* (AD). Photos by J. Kellermann.

— *Trymalium daphnoides* Reissek, *Linnaea* 29(13): 278 (1858). — *Spyridium spathulatum* F.Muell. ex Benth., *Fl. Austral.* 1: 430 (1863), *nom. superfl. & illeg.* — *Cryptandra spathulata* F.Muell., *Syst. Census. Austral. Pl.* 61 (1882), *nom. illeg.* — **Type citation:** "On the stony ranges near Mount Lofty, in South Australia, and in Kangaroo Island". **Lectotype (here designated):** Barren stony Ranges near Mount Lofty & Glen Osmond, 2 Mar. 1848, *F. Mueller s.n.* (MEL225572). **Residual syntypes:** Lofty Ranges, South Australia, Dec. 1847, *F. Mueller s.n.* (K000618739); Mount Lofty Ranges near St Vincents Gulf, Nov. 1848, *F. Mueller s.n.* (MEL225573); Third Creek, Nov. Holl. Austral. / Lofty Range, *F. Mueller s.n.* (MEL225576; labelled by Mueller as "Trymalium (Pomaderris?) / spathulatum FerdMll." and by Reissek as "Spyridium daphnoides / Trymalium Reiss."); Kangaroo Island, *s.coll.* (MEL225577).

Pomaderris spathulata Reissek, *Linnaea* 29(3): 278 (1858), *nom. inval. pro syn.*

Cryptandra obovata auct. non Hook.f.: Tate, *Handb. Fl. Extratrop. S. Austral.* 97 (1890).

Distribution. Endemic to South Australia on southern Eyre Peninsula, Kangaroo Island, the Mount Lofty region and the south-east of the State.

Common name. Spoon-leaved spyridium (Canning & Jessop 1986).

Typification. There are several specimens available at MEL, where Mueller worked, and one specimen at K. The lectotype has one flowering branch and the label corresponds with the type citation. The syntype specimen from Kangaroo Island was possibly collected by Carl Wilhelmi. MEL225576 was also seen by Reissek when describing *Trymalium daphnoides*.

Note. Reissek (1848) also published another similar species name, *Trymalium daphnifolium* Reissek, for specimens collected by James Drummond in Western Australia (but this is not a homonym of *T. daphnoides*).

Specimens examined by Reissek. In the protologue of *Trymalium daphnoides*, Reissek (1858) cites two collections: "Austral. merid. (Dr. F. Müller). Foot of the Marble ranges (Wilhelmi)." Some specimens matching these details are listed below, but there might be more collections in other herbaria. As discussed above, the name is typified on original material of *Trymalium spathulatum* and therefore the material cited by Reissek is not type material.

Specimens seen by Bentham. When describing *Spyridium spathulatum*, Bentham (1863) stated that he examined the following specimens: "South coast, *R. Brown* ; Lofty Ranges, *F.Mueller* ; foot of the Marble range, *Wilhelmi* ; Kangaroo Island, *Waterhouse*". As discussed above, the name is homotypic with *Trymalium daphnoides*; hence the specimens examined by Bentham are not type material.

Other historic material examined

Port Lincoln, *R. Brown Iter Austral. 5350* (K000618712); Bay X South Coast, Mar. 1802, *R. Brown Iter Austral. 5351* (BM); Bay X South Coast, *R. Brown s.n.* (K, "comm. J.J. Bennett"; BM; E00770107, photo seen; MEL225571; NSW811428; NSW811429; P06786091, photo seen); South Coast, *R. Brown s.n.* (CANB278620; CANB278621); Austral. meridion., *Dr. F. Müller s.n.* (LD1025070, photo seen); Foot of the Marble range, Feb. 55, *C. Wilhelmi s.n.* (K000618738, ex Herb. Hooker; TCD0013851, photo seen); Foot of the Marble Ranges / Port Lincoln, 1855, *C. Wilhelmi s.n.* (MEL225568); Foot of the Marble Range, *C. Wilhelmi s.n.* (MEL225569).

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Nomenclature and typification of several pre-1958 names in *Trymalium* revisited (Rhamnaceae: Pomaderreae)

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Abstract: The typification of six taxa of *Trymalium* Fenzl is reviewed. Lectotypes are designated for *T. angustifolium* Reissek, *T. daphnifolium* Reissek, *T. ledifolium* var. *rosmarinifolium* (Steud.) Benth. (basionym: *Pomaderris rosmarinifolia* Steud.) and *T. odoratissimum* Lindl., as well as for the heterotypic synonyms *Cryptandra anomala* Steud., *C. floribunda* Steud., *C. glaucophylla* Steud., *P. westringiifolia* Steud., *T. billardierei* var. *tomentoso-hirsutum* Fenzl, *T. floribundum* Steud. and *T. ledifolium* var. *obovatum* Benth. Three names published for plants cultivated in Paris in the 1840s (*Trymalium albidum* Jacques, *T. candidum* Neumann and *T. incanum* J.F.Cels & A.Cels) are discussed and are tentatively referred to *T. odoratissimum* Lindl. subsp. *odoratissimum*.

Keywords: Nomenclature, typification, Rhamnaceae, Pomaderreae, *Trymalium*, cultivated plants

Introduction

Trymalium Fenzl is one of the smaller genera of Rhamnaceae in Australia, with twelve species distributed in south-western Western Australia and one species occurring in South Australia. Two species found in the Grampians, Victoria, were transferred to *Spyridium* by Kellermann (2006).

The typification of several species of *Trymalium* was reviewed by Kellermann *et al.* (2008). These authors indicated a "holotype" for many accepted taxa and their synonyms, but, as McNeill (2014) and Mosyakin *et al.* (2019) have pointed out, holotypes for names published before 1958 only exist in very few instances. In most cases, it is recommended that a lectotype should be chosen. This advice is followed here and lectotypifications are published for most of the remaining names.

Kellermann *et al.* (2008) selected a lectotype of *Trymalium urceolare* (F.Muell.) Benth. and *T. wayi* F.Muell. & Tate, as well as a neotype of *T. litorale* (Diels) Domin. *Trymalium spatulatum* (Labill.) G.Don was lectotypified in a separate paper (Kellermann 2021b).

For names published by Steudel (1845) in *Plantae Preissianae*, Kellermann *et al.* (2008) usually indicated that the "holotype" was in LD, where Preiss' standard reference set is located (Crisp 1983; Orchard 1999). However, Steudel's own herbarium, which contains duplicates of Preiss' collections, is at P and the specimens there are usually annotated by Steudel; as such, some of these are chosen here as lectotypes of his names. In other words, some of the "holotypes" listed in Kellermann *et al.* (2008) are here re-visited, but deliberately not chosen as lectotypes in favour of Steudel's specimens at P. Since Kellermann *et al.* (2008) was published after 1 January 2001 their indications of a "holotype" do not constitute inadvertent lectotypifications (Art. 9.10; Turland *et al.* 2018), as from that date the phrase "here designated" was required to effect lectotypification of names.

Reissek (1848) published a synopsis of Western Australian Rhamnaceae in the Appendix for *Plantae Preissianae*, in which many of the taxa described by Steudel (1845) were revised or synonymised with other species – seemingly because Steudel's treatment of the family was not considered rigorous enough. Reissek also had more herbarium material available to him.

The following species and infraspecific taxa were described more recently by Rye (1995, 1996, 2000) and their typifications do not need to be reviewed: *Trymalium densiflorum* Rye, *T. elachophyllum* Rye, *T. ledifolium* var. *lineare* Rye, *T. monospermum* Rye, *T. myrtillus* subsp. *pungens* Rye, *T. odoratissimum* subsp. *trifidum* (Rye) Kellermann, Rye & K.R.Thiele (as *T. floribundum* subsp. *trifidum* Rye) and *T. venustum* Rye.

In this paper, type specimens that were examined in person are indicated with an exclamation mark (!). Digital images of all other specimens were viewed online at JSTOR Global Plants (JSTOR 2021) or other herbarium websites. Photos of specimens at CGE taken by J. Wege during a visit to that institution were also examined. Specimens that have not been seen in person or as an image are indicated by "*n.v.*".

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Nomenclature

Trymalium angustifolium Reissek

in Lehm., *Pl. Preiss.* 2: 284–285 (1848). — *Cryptandra angustifolia* (Reissek) F.Muell., *Syst. Census Austral. Pl.* 60 (1882). — **Type citation:** "Ad fl. Cygnorum (Drummond!)." **Lectotype (here designated):** Swan River, 1838, *J. Drummond s.n.* (W0046836, top specimen, accessioned 1840). **Residual syntype:** "Nov. Holl. austr. occ." [south-western Australia], *J. Drummond 719* (W0046836, bottom three branches, accessioned 1844, the middle branch with label: "Ist von Steud[el] nicht beschrieb[en] im I vol", i.e. "Was not described by Steudel in Vol. 1"). **Possible syntypes:** Swan River, *J. Drummond 719* (K000349029!, ex Herb. Saunders; P06831709, ex BM); W. Australia, *J. Drummond 719* (P06831709); Swan River, *J. Drummond 143* (K000349025!, ex Herb. Hooker); Swan River, *J. Drummond s.n.* (CGE; G ×3, photo at MEL; K000349026!, ex Herb. Hooker; K000349027!, ex Herb. Hooker, mounted on same sheet as K000349026; K000349028!, ex Herb. Saunders; MEL 56053!); Swan River, 1839, *J. Drummond s.n.* (CGE; K000349024!, ex Herb. Bentham); W.A., *J. Drummond s.n.* (MEL 56052!); Swan River, *J. Drummond 3* (E00770103).

Typification. As Reissek (1848) only provided very general collecting details, there are several specimens that are potentially original material. The type sheet at W, where Reissek worked, contains two *Drummond* collections: The top specimen is selected above as lectotype, as the branch label corresponds to the protologue ("fl. Cygnorum" = "Swan River"); the bottom collection has three branches and a less specific collection locality. It also includes an annotation that the specimen had not been described in Steudel's (1845) Rhamnaceae treatment.

Note. *Trymalium angustifolium* is endemic to south-west Western Australia, from Mt Lesueur along the Darling Range to near Wandering, generally in jarrah (*Eucalyptus marginata*) and wandoo (*E. wandoo*) forests and woodlands on lateritic soils.

Trymalium daphnifolium Reissek

in Lehm., *Pl. Preiss.* 2: 283–284 (1848). — *Trymalium ledifolium* var. *daphnifolium* (Reissek) Benth., *Fl. Austral.* 1: 424 (1863). — **Type citation:** "Ad fl. Cygnorum (Drummond!)". **Lectotype (here designated):** Swan River, *J. Drummond s.n.* (W0046833, specimen on right-hand side). **Remaining syntype:** Australasia austr. occid., *J. Drummond s.n.* (W0046833, specimen on left, fruiting). **Possible syntypes:** Swan River to Cape Riche, *J. Drummond 5: 237* (K349032!; P0676665); Swan River, *J. Drummond 237* (?LD1097165 *n.v.*); Swan River, W.A., *J. Drummond s.n.* ["with no. *720*"] (K349035!, ex Herb. Saunders); Swan River, *J. Drummond s.n.* ["No. 720 or 237?"] (K349034!); Swan River, *J. Drummond s.n.* (K349031!; K349033); W.A., *J. Drummond s.n.* (MEL56126!; MEL76340!; MEL 76341!).

Typification. As for the lectotype of Reissek's *Trymalium angustifolium* selected above, the type sheet for *T. daphnifolium* at W also contains two collections, both of them by James Drummond. The specimen on the right-hand side includes flowering material and is designated in this paper as the lectotype of the name. There are many duplicates of Drummond collections available in other herbaria, which are all possible syntypes. It is not clear, which collecting number is associated with the type, 237 or 720.

Note. The species occurs in south-west Western Australia, between Geraldton and Hyden, with an isolated record near Ravensthorpe, in woodlands and shrublands on sandy and loamy soils.

Trymalium ledifolium Fenzl

in Endl. *et al.*, *Enum. Pl.* 24 (1837). — **Type citation:** "*King Georges Sound.* (Hügel.)." **Holotype:** King George's Sound [but probably collected in the vicinity of Perth], *K.A.A. von Hügel s.n.* (W1996-0008124).

Cryptandra floribunda Steud. in Lehm., *Pl. Preiss.* 1: 186–187 (1845). — **Type citation:** "In limosis ad fluvium Cygnorum Juli 1839. Herb. Preiss. No. 1675." **Lectotype (here designated):** In solo limoso ad fl. Cygnorum prope praedium rusticum D. Gregory et in valle cataractae, 1 July 1839, *L. Preiss 1675* (LD1068175, determined by Steudel & Reissek). **Isolectotypes:** In solo limoso ad fl. Cygnorum prope praedium rusticum D. Gregory et in valle cataractae, 1 July 1839, *L. Preiss 1675* (P06766663, ex Herb. Steudel; W1889-0316770, ex Herb. Reichenbach); In limosis ad fluvium Cygnorum, July 1839, *L. Preiss 1675* (HBG510060; P06766659, ex Herb. Drake; P06766662, ex. Herb. Cosson & de Franqueville); In Nova Hollandia, Swan River Colonia, ad flumen Cygnorum in limosis, *L. Preiss 1675* (MEL56117!, ex Herb. Sonder); N. Holl – Riv. Des Cygnes, *L. Preiss 1675* (P06766648); "Fl. Cyc." [Flumen Cygnorum], *L. Preiss 1675* (K000732058, ex Herb. Reichenbach & Hooker, left specimen); "Sw. ri." [Swan River], *L. Preiss 1675* (K000732058, ex Herb. Hooker, right specimen); Nov. Holland. occ. austr., *L. Preiss 1675* (M0217862!); Nuova Ollanda, *L. Preiss 1675* (FI010478, "Com: dal Sig:re Preiss in Febb:io 1846"); Australasia, *L. Preiss 1675* (W1996-0008125); *s.loc.*, *L. Preiss 1675* (BR0000013468248; L2327509; P 06831834, ex Herb. Lenormand; S11-13081, ex Herb. Lehmann).

Trymalium ledifolium Fenzl var. ***ledifolium***: Benth., *Fl. Austral.* 1: 424 (1863).

Typification. Only one specimen of Hügel's collection of *Trymalium ledifolium* from Western Australia is known to exist; as such, this specimen at W is accepted as holotype of the name. The incorrect location on the label is discussed in Kellermann *et al.* (2008).

Preiss' specimens are distributed in many herbarium collections. The specimen of *Cryptandra floribunda* from the Preiss Herbarium at LD is designated above

as the lectotype. It is a well-preserved flowering branch, has an original collecting label and was determined by Steudel as *C. floribunda* and by Reissek as *Trymalium ledifolium*. There is a specimen from the *Preiss 1675* gathering in Steudel's personal herbarium at P; however, it was not determined by him as *C. floribunda*.

Note. The typical variety of *Trymalium ledifolium* grows along the Western Australian coast from north of Green Head south to near Bunbury, in heathlands and shrublands on limestone and calcareous dunes.

Trymalium ledifolium var. ***rosmarinifolium*** (Steud.) Benth.

Fl. Austral. 1: 424 (1863). — *Pomaderris rosmarinifolia* Steud. in Lehm., *Pl. Preiss.* 1: 184–185 (1845). — *Trymalium rosmarinifolium* (Steud.) Reissek in Lehm., *Pl. Preiss.* 2: 283 (1848). — **Type citation:** "In calcareis fruticosis ad tergum montis Baldhead 16 Oct. 1840. Herb Preiss No. 1674." **Lectotype (here designated):** In calcareis inter frutices ad tergum montis "Baldhead" (Plantagenet), 16 Oct. 1840, *L. Preiss 1674* (LD1068303, determined by Steudel & Reissek). **Isolectotypes:** In nova Hollandia, Swan River Colonia, ad tergum montis Baldhead, *L. Preiss 1674* (MEL56115!, ex Herb. Sonder); In calcareis inter frutices ad tergum montis Baldhead (Plantagenet), 16 Oct. 1840, *L. Preiss 1674* (MEL56119!; P06766673, ex Herb. Steudel); N. Holl – Riv. Des Cygnes, *L. Preiss 1674* (P06766646); Australia, 16 Oct. 1840, *L. Preiss 1674* (MO357435); Australasia, *L. Preiss 1674* (W0046831); *s. loc.*, *L. Preiss 1674* (L2327510; S11-13080; W1889-0316771, ex Herb. Reichenbach).

Pomaderris westringiifolia Steud. in Lehm., *Pl. Preiss.* 1: 185 (1845), as "*westringiaefolia*". — *Trymalium westringiifolium* (Steud.) Reissek in Lehm., *Pl. Preiss.* 2: 284 (1848), as "*westringiaefolium*". — *Spyridium westringiifolium* (Steud.) Benth, *Fl. Austral.* 1: 431 (1863), as "*westringiaefolium*". — *Cryptandra westringiifolia* (Steud.) F.Muell., *Syst. Cens. Austral. Pl.* 61 (1884), as "*westringifolia*". — **Type citation:** "In planitie clivuli calcarei Arthur'shead [*sic*] 23 Aug. 1839. Herb. Preiss. No. 1686." **Lectotype (here designated):** In planitie clivuli calcarei Arthur'shead, 23 Aug. 1839, *L. Preiss 1686* (LD1068367, determined by Steudel & Reissek). **Isolectotype:** In planitie clivuli calcarei Arthurshead, 23 Aug. 1839, *L. Preiss 1686* (MEL227039!).

Cryptandra anomala Steud. in Lehm., *Pl. Preiss.* 1: 187 (1845). — **Type citation:** "In N. Holl. occ.-austr. Herb. Preiss. No. 1685". **Lectotype (here designated):** In N. Holl. occ. austr., Nov. 1840, *L. Preiss 1685* (P06766664, specimen with flowers and early fruit, ex Herb. Steudel). **Isolectotypes:** In Nova Hollandia australi-occidentali (Swan River Colonia), *L. Preiss 1685* (MEL56120!, flowers and early fruit, ex Herb. Sonder); In reg. int. Austr. mer.-occid., Nov. 1840, *L. Preiss 1685* (LD1010814, determined by Steudel & Reissek, sterile specimen). **Possible isolectotype:** *s.loc.*, *L. Preiss 1685* (MEL56116A!, sterile specimen on left hand side).

Cryptandra glaucophylla Steud. in Lehm., *Pl. Preiss.* 1: 187 (1845). — **Type citation:** "In asperis montis Greenmountain 27 Jul. 1839. Herb Preiss No. 1684." **Lectotype (here designated):** In asperis montis Greenmountain, N. Holl. occ. austr., *L. Preiss 1684* (P06766658, ex Herb. Steudel). **Isolectotypes:** In asperis montis Greenmountain, 27 July 1839, *L. Preiss 1684* (MEL56118!); In asperis montis "Greenmountain", 27 July 1839, *L. Preiss 1684* (LD1068239, determined by Steudel & Reissek).

Fig. 1. *Trymalium ledifolium* var. *rosmarinifolium* at Boonanarring Brook Reserve, north of Gingin (Western Australia). **A** Young shrub growing in eucalypt woodland; **B** inflorescence. — *J. Kellermann 180* (AD). Photos: J. Kellermann.

Typification. *Pomaderris rosmarinifolia* and *P. westringiifolia* are both lectotypified by specimens in LD, which were annotated by Steudel and Reissek. For *Cryptandra anomala* and *C. glaucophylla* the lectotypes are instead chosen from Steudel's herbarium in P; in contrast to the LD material for these two species, the lectotype of *C. anomala* is better preserved and in flower, while that of *C. glaucophylla* is much larger.

Note. *Trymalium ledifolium* var. *rosmarinifolium* (Fig. 1) occurs in south-west Western Australia and extends from near Badgingarra south along the Darling Range to Cape Leeuwin, Albany and the Stirling Range, in woodlands and forests on clays, loams and sandy soils, particularly over laterite.

Trymalium myrtillus S.Moore

J. Linn. Soc., Bot. 34: 183–184 (1899). — **Type citation:** "Viget prope Coolgardie, ubi mens. Aug. floret." **Holotype:** "Shrub 4 feet high / yellowish white flowers", Near Coolgardie, Western Australian Goldfields, Aug. 1895, *S. Moore s.n.* (BM001014733). **Isotypes:** K000732054 (with detailed drawing of flower); NY00415075.

Trymalium myrtillus S.Moore subsp. ***myrtillus***: Rye, *Nuytsia* 11: 110 (1996).

Typification. Moore (1899: 177) stated in the introduction of his account of plants collected in the interior of Western Australia that "[T]he first set of plants […] is at the British Museum" and that "second and third sets" have been sent to "Columbia College, New York" (now incorporated into NY) and to K, respectively. As the author definitely indicated where the primary set of specimens is located, the specimen at BM is here accepted as holotype (see McNeill 2014; Mosyakin *et al.* 2019).

Note. *Trymalium myrtillus* subsp. *myrtillus* is endemic to south-west Western Australia, in woodland and mallee shrubland, often on granite, between the Die Hardy Range, Lake Grace, Bremer Bay and Balladonia.

Trymalium odoratissimum Lindl.

Edwards's Bot. Reg. 24: *Misc.* 26 (1838). — **Type citation:** "The species […] was introduced from Swan River by R. Mangles, Esq. by whom a plant in flower was presented to the Horticultural Society of London in February 1838". **Lectotype (here designated):** Sheet with no indication of location, date or collector at CGE (ex Herb. Lindley), illustrated in Kellermann, Rye & K.R.Thiele, *Trans. Roy. Soc. S. Austral.* 132: 21, Fig. 1 (2008). **Possible syntype:** "specimen in Anglia cultum" (MEL56077!).

Trymalium billardierei var. [β] *tomentoso-hirsutum* Fenzl in Endl. *et al.*, *Enum. Pl.* 25 (1837), as "*Billardieri*" and "*tomentoso-hirsuta*". — *Trymalium billardierei* var. [β] *calvescens* Reissek in Lehm., *Pl. Preiss.* 2: 282 (1848), *nom. superfl. & illeg.*, as "*Billardieri*" — *Spyridium spadiceum* var. *calvescens* Benth., *Fl. Austral.* 1: 282 (1863), *nom. superfl. & illeg.* — **Type citation:** "*Swan-River*. (Hügel.)". **Lectotype (here designated):** Swan River, *K.A.A. von Hügel s.n.* (W0046834, labelled as "β ~~tomentosa~~ glabrescens"). **Possible syntype:** [Hort. Hietzing, 1841,] *K.A.A. von Hügel s.n.* (K349018, right-hand specimen on sheet).

Trymalium floribundum Steud. in Lehm., *Pl. Preiss.* 1: 185 (1845). — **Type citation:** "In sublimosis saxosis ad latus praeruptum vallis Cataractae ad caput fluvii Cygnorum 25. Jul. 1839. Herb. Preiss No. 1680." **Lectotype (here designated):** Swan-River, In sublimosis saxosis ad latus praeruptum vallis Cataractae ad originem fluvii Cygnorum, 25 July 1839, *L. Preiss 1680* (P00643757, ex Herb. Steudel, annotated by Steudel). **Isolectotypes:** In solo sublimoso inter saxa ad latus praeruptum vallis Cataractae ad caput fl. Cygnorum, 25 July. 1839, *L. Preiss 1680* (LD1010430, annotated by Steudel & Reissek); In Nova Hollandia, (Swan River Colonia, in valle Cataractae ad caput fluminis Cygnorum), *L. Preiss 1680* (MEL56071!, ex Herb. Sonder); Swan-River, In sublimosis saxosis ad latus praeruptum vallis Cataractae ad caput Fluvii Cygnorum, 25 July 1839, *L. Preiss 1680* (P00643758, ex Herb. Drake); Ad flum. Cygnorum, *L. Preiss 1680* (MEL56070!; W18890316768); N. Holl. – Riv. Des Cygnes, *L. Preiss 1680* (P06766682); Western Australia, *L. Preiss 1680* (MEL56072!); Nov. Holland. Occ. austr., *L. Preiss 1680* (M0211893!); Australia, *L. Preiss 1680* (MO-2366294, ex Herb. Bernhardi); Nuova Ollanda, *L. Preiss 1680* (FI010477); Australasia, *L. Preiss 1680* (HBG510059); *s.loc.*, *L. Preiss 1680* (S11-13082); *s.loc.*, *L. Preiss 1680* (BR0000013526085; L2327496; W0046832, mounted on same sheet as *Preiss 1682*, *Drummond II 718* and an unnumbered Drummond collection).

Trymalium expansum Steud. in Lehm., *Pl. Preiss.* 1: 185 (1845). — **Type citation:** "In rupestribus ad clivulum vallis Toodyayvalley ditionis Victoria. 7. Mart. 1840. Herb. Preiss. No. 1683." **Holotype:** In rupestribus ad clivulum vallis 'Toodyayvalley' (Victoria), 7 Mar. 1840, *L. Preiss 1683* (LD1010366).

Trymalium billardierei var. [α] *tomentosum* Reissek in Lehm., *Pl. Preiss.* 2: 282 (1848), as "*Billardieri*" and "*tomentosa*". — *Trymalium billardierei* var. *hirsutum* Benth., *Fl. Austral.* 1: 424 (1863), *nom. superfl. & illeg.*, as "*Billardieri*" (in error for var. *tomentosum*). — *Trymalium spatulatum* var. *tomentosum* (Reissek) Ostenf., *Biol. Meddel. Kongel. Danske Vidensk. Selsk.* 3(2): 85 (1921), as "*spathulatum*". — **Type citation:** "Ad King Georges Sound (Hügel!); in rupestris ad clivulum vallis Toodgayvalley [*sic*] (Victoria) 7. Mart. 1840 fructifera, (Hb. Preiss. No. 1683); in solo sublimoso inter saxa ad latus praeruptum vallis cataractae ad caput fl. Cygnorum (25. Jul. 1839 florens Herb. Preiss. No. 1682); ad fluv. Cygnorum. Herb. Preiss. No. 1680. (Drummond. Coll. II. No. 718)." **Lectotype:** Halfway House, Darling Ranges, W.A., 13 Sep. 1839, *L. Preiss 1682* (LD1010494, annotated by Steudel & Reissek), *fide* Kellermann, Rye & K.R.Thiele, *Trans. Roy. Soc. S. Austral.* 132: 23 (2008). **Isolectotypes:** In Halfway house (Darling ranges), *L. Preiss 1682* (MEL56103!); N. Holl. – Riv. Des Cygnes, *L. Preiss 1680* (P

06766683); W.A., *L. Preiss 1682* (MEL56097!); Australia, *L. Preiss 1682* (MO-2366295, ex Herb. Bernhardi); Australasia, *L. Preiss 1682* (W0046832, mounted on same sheet as *J. Drummond 718*); *s.loc.*, *L. Preiss 1682* (L2327495). **Remaining syntypes:** *L. Preiss 1680* (see *T. floribundum* for details); *L. Preiss 1683* (see *T. expansum* for details); King Georges Sound, *K.A.A. von Hügel s.n.* (W0046835, labelled as "var. α ~~calvescens~~ hirsuta"); Nouvelle Hollande occidentale, R. des cygnes (Swan-river), *J. Drummond 718* (P06766696); Swan River, *J. Drummond 718* (W0046832); W.A., *J. Drummond 718* (MEL56099!); W. Australia, *J. Drummond 718* (P06766691, ex BM); Swan River, *J. Drummond s.n.* (K000349019; K000349022); *s.loc.*, *J. Drummond s.n.* (W0046832).

Trymalium ledifolium var. *obovatum* Benth., *Fl. Austral.* 1: 424 (1863), as "var. (?) *obovatum*". — **Type citation:** "Rocks at Todyay [*sic*], *Oldfield*. The specimens are small and in bud only". **Lectotype (here designated):** Rocks at Toodyay, Western Australia, *A.F. Oldfield s.n.* (K349030, ex Herb. Hooker, with detailed drawing of flower). **Possible isolectotype:** "Spreading shrub 2–3ft, fragrant", Rocks Toodyay, *A.F. Oldfield 427* (MEL56121!).

Trymalium odoratissimum Lindl. subsp. ***odoratissimum***: Kellermann, Rye & K.R.Thiele, *Trans. Roy. Soc. S. Austral.* 132: 23 (2008). — *Trymalium floribundum* Steud. subsp. *floribundum*: Rye, *Nuytsia* 10: 133 (1995).

***Typification of* Trymalium odoratissimum.** Kellermann *et al.* (2008) listed two specimens of *Trymalium odoratissimum* and incorrectly stated that one of them is the "holotype". Following McNeill (2014), the specimen from Lindley's herbarium at CGE is above selected as the lectotype of the name.

Typification of* T. billardierei *varieties. When Fenzl (1837) published *Trymalium billardierei* he included the earlier *Ceanothus spatulatus* Labill. in synonymy; hence Fenzl's species name is illegitimate, as he should have taken up the available epithet *spatulatum* (Kellermann 2021b). Of the two varieties he included, the first, var. [α] *dense-tomentosa*, was intended to be the typical variety, as he listed the type of *C. spatulatus* and a specimen collected by Hügel under specimens examined: "*In terra Van - Leuwin* (Labill.), _ *King Georges Sound*. (Hügel)." (however, the Hügel collection is actually material of *T. odoratissimum*, not *T. spatulatum*). The first varietal name is thus not validly published. The second variety published by Fenzl is var. [β] *tomentoso-hirsutum*, typified by another Hügel collection held at W.

Reissek (1848) also listed *Trymalium billardierei* in his enumeration of Rhamnaceae in Western Australia, but he explicitly excluded Labillardiere's *C. spatulatus*, meaning that his concept of *T. billardierei* was different from Fenzl's. However, as the name *T. billardierei* is illegitimate it cannot be applied at species level. Reissek took up Fenzl's two varieties and enumerated them, but with slightly different epithets, as *T. billardierei* var. [α] *tomentosum* and var. [β] *calvescens*. Since Labillardiere's collection was excluded from the first variety, this variety now has a validly published and legitimate name. Reissek's second varietal name is superfluous and illegitimate, however, as it is typified by the same specimen as Fenzl's var. *tomentoso-hirsuta*.

As discussed in Kellermann *et al.* (2008), there is one sheet at W with Hügel's collection of *T. billardierei* var. *tomentoso-hirsutum*, and a possible further syntype at K. The specimen at W is designated above as the lectotype. The other variety, *T. billardierei* var. *tomentosum*, was lectotypified in Kellermann *et al.* (2008).

***Typification of* T. floribundum *and* T. expansum.** The lectotype designated above for *Trymalium floribundum* is not the "holotype" at LD that was listed by Kellermann *et al.* (2008), as the specimen from Steudel's herbarium at P is larger and in better condition than the specimen in LD. The P specimen was also annotated by Steudel.

As discussed in Kellermann *et al.* (2008), only one Preiss specimen of *T. expansum* could be located and this is accepted as the holotype of the name. The specimen is in quite bad condition, consisting of a bare leafless branch with some small fragments of leaves and a few flowers in a fragment packet.

***Typification of* T. ledifolium *var.* obovatum.** Two specimens collected by Oldfield have been located. The material at K is designated as the lectotype above, as it was seen by Bentham.

Note. The typical subspecies of *Trymalium odoratissimum* is endemic to south-west Western Australia, from the vicinity of Mt Lesueur along the Darling Range to the Murray and Williams Rivers, with a few records further south, in forests, woodlands and shrublands, often along streams. There is minor intergradation or hybridisation between the two subspecies where they co-occur.

Doubtful names for cultivated material

Trymalium albidum Jacques

Rev. Hort. J. Jard. Amateurs 6(2): 26 (1844). — **Type citation:** "Je l'ai vu en fleur, en mars 1844, au Jardin des Plantes de Paris". — **Specimen:** "h.[ortus] Par.[is] 1843 [*or* 1849].", *Anon. s.n.* (P06831809, ex Herb. Spach).

= ?*Trymalium odoratissimum* Lindl. subsp. *odoratissimum*

Trymalium candidum Neumann

Art Construire Gouverner Serres 51 (1844), *nom. nud. & inval.* — **Specimen:** "Avril. 1843. Orang.[erie], hort.[us] Cels.", *Anon. s.n.* (P06831810, ex Herb. Houllet).

= ?*Trymalium odoratissimum* Lindl. subsp. *odoratissimum*

Trymalium incanum J.F.Cels & A.Cels

Extr. Cat. Cult. Frèr. Cels 2: 15 (1844), *nom. nud. & inval.*

= ?*Trymalium odoratissimum* Lindl. subsp. *odoratissimum*

Note. These three names relating to plants cultivated in Paris all appeared in print in 1844 and they possibly refer to the same taxon, as the epithets have almost the same meaning in Latin: *albidum* (white), *candidum* (shining white), *incanum* (grey hairy). These possibly refer to the colour of the lower leaf surface, which is densely hairy, or to the flower colour.

Jacques (1844) provided an account of *Trymalium* species in cultivation at the time, namely: *T. spatulatum* (Labill.) G.Don (Kellermann 2021b); *T. capsulare* (G.Forst.) G.Don, a synonym of *Colubrina asiatica* (L.) Brongn. (Kellermann 2021a); *T. wendlandianum* (Schult.) Sweet, a synonym of *Pomaderris ferruginea* Sieber ex Fenzl; and *T. albidum* Jacques. He gave short descriptions for all four species and stated that he had observed *T. albidum* in the botanic garden of Paris, meaning that since he wrote the description from live material, there might not be an original specimen. Jacques also mentioned the sales catalogue of the nursery of the Cels brothers (Cels & Cels 1844) and stated that *Trymalium incanum*, mentioned in the catalogue, could very likely be *T. albidum*. The name *T. candidum* was mentioned in Neumann (1844) in a list of plants that can be grown in temperate glasshouses.

Thanks to the fact that the holdings of herbarium P are now fully available online (Le Bras *et al.* 2017), it was possible to view digital images of two specimens that were collected in French gardens in the 1840s and are labelled as *Trymalium albidum* and *T. candidum*; they are listed above and shown in Fig. 2. In both cases these horticultural names are attributed to "Ad.[olphe Théodore] Brongn.[iart]" on the specimens, but they were not published by him.

The label on the specimen of *Trymalium albidum* is hard to read and the year of collection could be 1843 or 1849. The two specimens are very similar and it is possible that they are duplicates, or at least collected from the same plant; they also both have a similar note attached, with the same handwriting. As the specimen of *T. albidum* was collected in 1843 or 1849, but Jacques (1844) states that he drew up the description from a shrub he had seen flowering in March 1844, this specimen cannot be original material of *T. albidum*. However, both specimens are important records of the plants cultivated in Paris at the time and confirm the names listed in the books and nursery catalogues.

These two specimens are most likely *Trymalium odoratissimum* subsp. *odoratissimum*, but without examining flowers under the microscope to check if they have styles with two stigmatic lobes (which is not visible on scanned specimens), it is impossible to be sure of the subspecies. The other subspecies, *Trymalium odoratissimum* subsp. *trifidum*, has three stigmatic lobes, and leaves that "are usually larger and more acute [...] and often serrate" (Rye 1995: 134). The shape and size of the leaves on the two specimens also indicate that they may represent the typical subspecies.

No specimen could be found bearing the name *Trymalium incanum*. Since the specimen in P that is labelled *T. candidum* was collected at the gardens of the Cels brothers, it is feasible that this name refers to the same plant listed as *T. incanum* in their nursery catalogue. As such, all three names are considered here to be doubtful synonyms of *T. odoratissimum* subsp. *odoratissimum*.

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Fig. 2. Herbarium specimens of *Trymalium* plants cultivated in Paris in the 1840s, possibly representing *T. odoratissimum* subsp. *odoratissimum*. **A** *Trymalium albidum*: "h. Par.", 1843 or 1849, *Anon. s.n.* (P06831809). **B** *Trymalium candidum*: "Orang. hort. Cels", Apr. 1843, *Anon. s.n.* (P06831810). — Images courtesy of the Museum national d'Histoire naturelle, Paris, under a Creative Commons CC-BY 4.0 license (photos slightly cropped).

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SHORT COMMUNICATION

Validation of two names of Australian orchids

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During work on the Australian Plant Census lists for Orchidaceae (APC 2021), two currently used names (×*Glossadenia tutelata* and *Cadetia maideniana*) were found not to have been validly published. We rectify the situation in this paper by validating and typifying these names and discuss their taxonomic history.

×*Glossadenia* Kavulak

Austral. Nat. Orch. Hybr. Guide 7 (1986). — Stated parentage: *Glossodia* R.Br. × *Caladenia* R.Br.

×*Calassodia* M.A.Clem. ex D.L.Jones, *Nat. Orchids Austral.* 621 (1988). — Stated parentage: *Caladenia* R.Br. × *Glossodia* R.Br.

×*Calassodia* M.A.Clem., *Austral. Orchid Res.* 1: 33 (1989), isonym. — Stated parentage: *Caladenia* R.Br. × *Glossodia* R.Br.

×*Glossadenia* Jeanes in Jeanes & G.N.Backhouse, *Wild Orchids Vic. Austral.* 124 (2006), *non* Kavulak (1986) [later homonym]. — Stated parentage: *Glossodia* R.Br. × *Pheladenia* D.L.Jones & M.A.Clem.

×*Glossadenia* J.M.H.Shaw, *Quart Suppl. Int. Reg. Orchid Hybr. (Sander's List)* 122(1305): 16 (2014), *non* Kavulak (1986) [later homonym]. — Stated parentage: *Glossodia* R.Br. × *Pheladenia* D.L.Jones & M.A.Clem.

×*Glossadenia tutelata* (R.S.Rogers) Kellermann, *comb. nov.*

Caladenia ×*tutelata* R.S.Rogers, *Trans. Proc. & Rep. Roy. Soc. South Australia* 31: 211 (1907), *pro sp.* — ×*Calassodia tutelata* (R.S.Rogers) M.A.Clem., *Austral. Orchid Res.* 1: 33 (1989). — **Type citation:** "discoveries on August 24 of this year" [1907]. **Lectotype (here designated):** Blackwood, 24 Aug. 1907, *E. Ashby s.n.* (AD97522357). **Isolectotype:** Blackwood, 24 Aug. 1907, [*E.*] *Ashby s.n.* (AD97522358A; mounted with another specimen of the same taxon, collected on 23 Sep. 1912).

×*Glossadenia tutelata* Kavulak, *Austral. Nat. Orch. Hybr. Guide* 7 (1986), *nom. nud. & inval.*

×*Calassodia tutelata* D.L.Jones, *Nat. Orchids Austral.* 621 (1988), *nom. inval.*

Glossodia ×*tutelata* M.W.Harrison & M.J.G.Corrigan, *Checkl. Austral. Nat. Orch. Hybr. Ed. 5*, 24, 61 (1993), *nom. inval.*

×*Glossadenia tutelata* Jeanes in Jeanes & G.N.Backhouse, *Wild Orchids Vic. Austral.* 124 (2006), *nom. inval.*

Note. Kavulak (1986) published a list of Australian orchid hybrids, in which he proposed the name of a hybrid genus, ×*Glossadenia* Kavulak, with one species, ×*Glossadenia tutelata* Kavulak. The name of this nothogenus was published validly, via the statement that it is a hybrid between *Glossodia* R.Br. and *Caladenia* R.Br. However, the name of the nothospecies was not validly published according to the rules of the *International Code of Nomenclature for algae, fungi, and plants* (ICN; Turland *et al.* 2018). While the use by Kavulak (1986) of the epithet of an existing species name may indicate that he intended to base his nothospecies on *Caladenia* ×*tutelata* R.S.Rogers (Rogers 1907), he did not give a full and direct reference to a basionym as required by ICN Art. 41.5 for new combinations. He also did not provide a description or diagnosis of the hybrid species, or other information required for the publication of the name of a new taxon. Hence ×*Glossadenia tutelata* is a *nomen nudum* and not validly published. In subsequent editions of this hybrid list, as well as some other works (e.g. Clements 1989; Bates & Weber 1990; Mayfield 2006), the designation "×*Glossadenia tutelata*" is also used but in none of them is the name validly published.

A few years after Kavulak (1986), Jones (1988) published the hybrid genus ×*Calassodia* M.A.Clem. ex D.L.Jones (this time with the parent genera listed in alphabetical order), but as this nothogenus contained the same hybrid taxon as the earlier ×*Glossadenia* Kavulak, it is to be treated as a synonym (ICN Art. H.4.1). Clements (1989) was the first to publish the

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new combination ×*Calassodia tutelata* (R.S.Rogers) M.A.Clem., based on *Caladenia* ×*tutelata* R.S.Rogers.

Harrison & Corrigan (1993) list this hybrid taxon as *Glossodia* ×*tutelata* M.W.Harrison & M.J.G.Corrigan, apparently unaware that two nothogeneric names had been published for the taxon, and that the valid name *Caladenia* ×*tutelata* existed. Since they did not provide a full and direct reference to the intended basionym and its place of publication they did not validly publish a combination in *Glossodia*.

Jeanes (Jeanes & Backhouse 2006) published a nothogenus for hybrids between *Glossodia* R.Br. and *Pheladenia* D.L.Jones & M.A.Clem., as at this time, *Caladenia deformis* R.Br. had been transferred to a new genus as *Pheladenia deformis* (R.Br.) D.L.Jones & M.A.Clem. However, as he used the same name, ×*Glossadenia* Jeanes is a later homonym of Kavulak's (1986) name.

Fig. 1. ×*Glossadenia tutelata* (R.S.Rogers) Kellermann. **A** Side view; **B** front view; **C** back view; **D** enlargement to show the front view of column and labellum; **E** side view of column and labellum. Line drawing by F.J. Bradley, first published in Rogers (1906).

The new combination ×*Glossadenia tutelata* (R.S.Rogers) Kellermann is validated here for the name of this hybrid taxon, following the rules of the ICN.

Typification. Rogers (1906) described and illustrated (Fig. 1) a new *Caladenia* in detail, but because he was unsure about its status, he refrained from naming it. A year later, after receiving new material, Rogers (1907) published the name *Caladenia tutelata*, validating it by referring to his original description and adding some further notes on the plant. The first material of the taxon was provided to Rogers by "Mr. E. Ashby" and was "collected at Blackwood on September 16 of this year (1906)" (Rogers 1906: 225). However, in Rogers (1907) it is stated that the 1906 collection was provided by "Mr. A. Keith Ashby", the son of Edwin Ashby. Rogers may have confused the identity of the original collector. The type collection mentioned in the protologue was made "on August 24 [1907]" (Rogers 1907: 211) but the collector's name is not mentioned. It can be assumed that this material was also gathered by members of the Ashby family in Blackwood.

There are two specimens originally labelled as *Caladenia tutelata* in Rogers' herbarium, both collected by Edwin Ashby on 24 Aug. 1907. One of these was annotated by Rogers as being the type. No specimens of a 1906 collection of the species by either Ashby could be traced at AD, where Rogers' herbarium is stored. The sheet that Rogers annotated as "Type specimen" (AD 97522357) is here designated as the lectotype of the name.

Etymology. "The name *tutelata* (under protection) refers to the sentinel calli which appear to guard the entrance of the column" (Bates & Weber 1990).

Cadetia maideniana Schltr. ex Kellermann, *sp. nov.*

Based on this previously published description in English: Dockrill, *Austral. Indig. Orchids Ed. 2*, 1: 426 & 427 (line drawing) (1993). — **Holotypus:** Queensland, Cook District: Mossman Gorge, W of Mossman, 13 June 1972, *J. Wrigley & I. Telford NQ1103* (CBG43131 at CANB).

Dendrobium maidenianum Schltr., *Nachtr. Schutzgeb. Südsee* 156 (1905), *nom. nud. & inval.*

Cadetia maideniana Schltr., *Repert. Spec. Nov. Regni Veg. Beih.* 1: 424 & *adnot.* (1912), *nom. nud. & inval.*

Dendrobium hispidum auct. non A.Rich.: F.Muell., *Fragm.* 7(51): 30 (1869); Benth., *Fl. Austral.* 6: 283 (1873); Bailey, *Syn. Queensl. Fl.* 511 (1883); *Queensl. Fl.* 5: 1532 (1902).

Dendrobium taylorii auct. non (F.Muell.) F.M.Bailey: Fitzg., *Austral. Orchids* 2(3): pl. 7 (1888).

Cadetia hispida auct. non (A.Rich.) Schltr.: Dockrill, *J. Orchidol.* 2(3): 92 (1961).

Cadetia hispidula M.A.Clem., *Prelim. Checkl. Austral. Orch.* 24 (1982), *orth. var.* [in error for the misapplied name *Cadetia hispida*].

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HERBARIUM, CANBERRA BOTANIC GARDENS
No. 043131
Cadetia maideniana (Schltr.) Schltr.
Loc. QUEENSLAND: Cook district: Mossman Gorge, W of Mossman, 16° 28' S 145° 20' E
Notes Epiphyte on rain forest tree. Plants 72 2283
IBIS DATABASE
Coll. J. Wrigley & I. Telford
Date 13 · VI · 1972
Det. NQ 1103
PG4/3 (1969)
043131

Fig. 2. *Cadetia maideniana* Schltr. ex Kellermann, holotype (CBG43131 at CANB).

Note. Schlechter (1905) proposed the names *Dendrobium maidenianum* Schltr. and later *Cadetia maideniana* Schltr. (Schlechter 1912) for northern Australian specimens to which the name *D. hispidum* A.Rich. had previously been misapplied. However, in neither case did Schlechter provide a description or diagnosis of the species or a reference to a previously published description or diagnosis, but merely mentioned the new names. This is insufficient for valid publication of the name of a new taxon (see ICN Art 41 Note 3).

Although it had not been validly published, other authors used the name *Cadetia maideniana* in their publications for over a hundred years. Presumably because they believed that it had been published previously, they did not give a Latin description or diagnosis (as required from 1935–2012; ICN Art. 39.1), provide a direct reference to an already published valid description or diagnosis, or mention other information required for valid publication (e.g. citing a type specimen). As a result, the name has not been validated.

Typification. When it became apparent during the preparation of the APC list for Orchidaceae that this taxon did not have a validly published name available, a specimen was selected from the CANB collections to serve as a voucher for a phrase name in the format outlined by Barker (2005). To retain the species concept the phrase name *Cadetia* sp. Maideniana (*J.Wrigley NQ1103*) Australian National Herbarium was proposed, but never used in the APC. We have chosen to use the same specimen as the type specimen of the species (Fig. 2). It contains three small, well-preserved flowering plants.

A Dallachy specimen was cited by Clements (1989) as "Type"; this material had been examined by Ferdinand von Mueller when preparing his description of *Dendrobium hispidum* A.Rich. from Australian collections (Mueller 1869). However, since the name *Cadetia maideniana* is validated here, the Dallachy collection is not original material.

Etymology. The epithet honours the eminent New South Wales botanist Joseph Henry Maiden (1859–1925; Gilbert 2001) and was coined by Schlechter (1905).

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Schlechter, R. (1912) [1914]. Die Orchidaceen von Deutsch-Neu-Guinea. *Repertorium Specierum Novarum Regni Vegetabilis Beihefte* 1(27).

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Phebalium calcicola (Rutaceae: Boronieae): a species described as new, restricted to south-eastern South Australia, is proposed as Critically Endangered

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Abstract: *Phebalium calcicola*, a multi-stemmed shrub from south-eastern South Australia, is segregated from the *P. squamulosum* subsp. *squamulosum* assemblage and described here as new, based on phenetic distinctness, habitat preference and geographical disjunction. It is compared with *P. squamulosum* subsp. *squamulosum s.str.* from the Sydney region, as well as the geographically closest populations from Victoria, which are currently referred as *P. squamulosum* subsp. *squamulosum*. A recommendation for the conservation status of this species as Critically Endangered is proposed. An amended key to species of *Phebalium* in South Australia is provided.

Keywords: Critically Endangered, new species, phenetic analysis, Rutaceae, *Phebalium*, plant taxonomy, South Australia, SEM

Introduction

Phebalium Vent. (Rutaceae: Boronieae) is an Australian endemic genus of shrubs and small trees, which is widespread but patchy in distribution across eastern and southern Australia, from the coastal areas to high mountains. Currently, more than 30 species, including 20 from eastern Australia, are recognised (Wilson 2013; Telford *et al.* 2019; Ford & Duretto 2020).

The type species of the genus, *P. squamulosum* Vent., was described from a plant grown in Empress Joséphine's garden at Malmaison, France, which had originally been collected from the east coast of Australia: "originaire de la Nouvelle Galles, et croissant sur les montagnes" (Ventenat 1805; Wilson 1970). Callmander *et al.* (2017) designated a lectotype from the Geneva herbarium (G00340116).

Many species of *Phebalium* exhibit considerable morphological variation. Wilson (1970) noted this variation in the last major revision of the genus; however, he still accommodated much variation within several subspecies. *Phebalium squamulosum* subsp. *squamulosum* is one of the most variable, with highly disjunct elements (see maps in Wilson 1970, 2013). Wilson (1970: 82) discussed this variation and considered recognising more taxa, but decided against that "as some of these forms are known only from single collections".

Specimens collected since Wilson's 1970 treatment and concerted curation of *Phebalium* at BRI and NE has led to reassessment of the status of taxa within the genus. Indeed, classification within *Phebalium* has been confounded by the use of varietal (Bentham 1863; Wilson 1970) and subspecific categories (Wilson 1970, 1998). Forster (2003) questioned Wilson's concept of subspecies and reinstated *P. longifolium* S.T.Blake as a distinct species. Similarly, Telford & Bruhl (2014) raised *P. squamulosum* subsp. *verrucosum* Paul G.Wilson to specific rank.

The dismantling of *Phebalium squamulosum* subsp. *squamulosum* began with segregation of *P. distans* P.I.Forst. (Forster 2003), and continued with the recognition of *P. graniticola* I.Telford & J.J.Bruhl, *P. stellatum* I.Telford & J.J.Bruhl, and *P. sylvaticum* I.Telford & J.J.Bruhl (Telford *et al.* 2019). After the segregation of these species, *P. squamulosum* subsp. *squamulosum* is still highly variable and "forms" observed by Wilson (1970: 82, 2013: 472) are not fully addressed. His morphological description of the type form of *P. squamulosum* is "leaves elliptic, acute to entire, chartaceous or sub-coriaceous, and glabrous above" (Wilson 1970: 82), which is restricted to the Sydney Basin (Telford *et al.* 2019). As per Wilson's (1970, 2013) account of the subspecies, Victoria is the western-most range of occurrence of the subspecies, with at least three forms, differing from the typical subspecies in calyx rim, habit and in presence of trichomes on leaf and style. There is no mention of this subspecies occurring in South Australia in either Wilson (1970, 2013) or the *Flora of South Australia* (Armstrong & Telford 1986), although there are collections from as early as 1975. This taxon is recorded only since the

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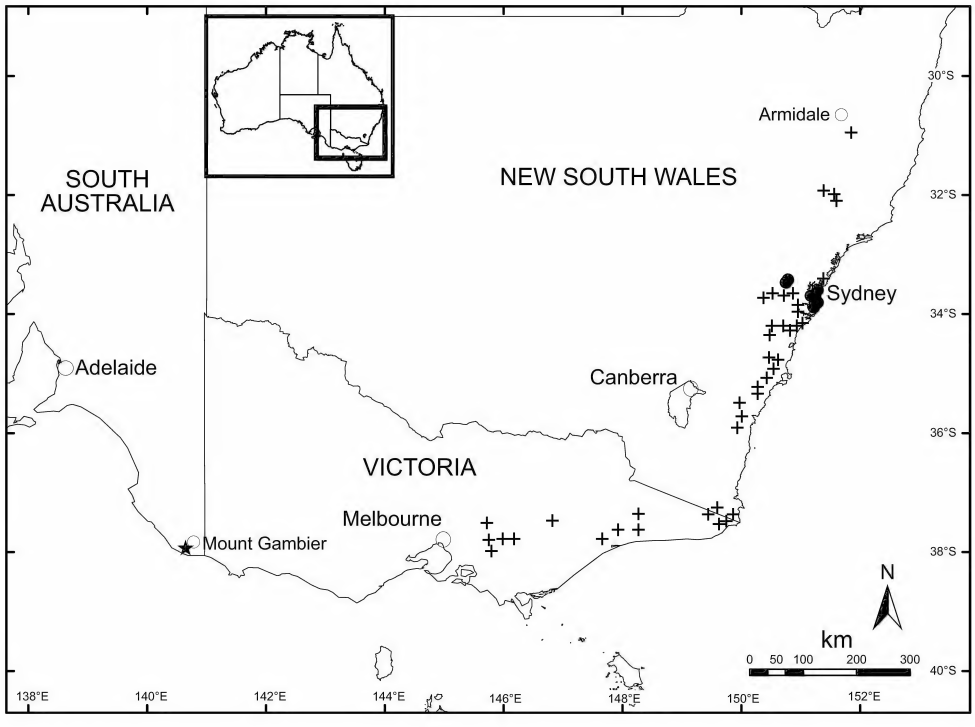

Fig. 1. Distribution of *Phebalium calcicola* (star), *P. squamulosum* subsp. *squamulosum s.str.* (solid circles) and *P. squamulosum* subsp. *squamulosum s.lat.* (crosses).

1989 census of South Australian Vascular Plants as *P. squamulosum* (Jessop 1989; see also Barker *et al.* 2005).

This paper is part of a work in progress aimed at addressing the variation within the remaining populations of *Phebalium squamulosum* subsp. *squamulosum s.lat.* (Fig. 1). Here, we focus on the South Australian occurrence, which comprises a single extant population in the extreme south-east of the state near Mt Gambier. This South Australian population, as *P. squamulosum* subsp. *squamulosum*, has been listed since 1992 as Endangered under the South Australian *National Parks and Wildlife Act 1972*. In the regional species status assessment of the South-Eastern region by Gillam & Urban (2011), this taxon was assessed to be Critically Endangered. In the most recent state-wide assessment workshop in 2016, it was also provisionally assessed as Critically Endangered (DEWNR 2016, unpublished data).

Materials & Methods

In earlier treatments and in the major revision of *Phebalium* by Wilson (1970, 1998), species and infraspecific taxa have been delimited and described largely based on morphological differences. Subsequent taxonomists working on *Phebalium* have continued to apply morphological approaches, with or without phenetic analysis, supplemented by additional lines of evidence from anatomical and phytochemical data (Forster 2003; Weston & Turton 2004; Giles *et al.* 2008; Telford & Bruhl 2014; Telford *et al.* 2019). In this paper, we use morphological distinctness and

Table 1. Morphological characters measured for phenetic analysis.

#	Character (units)
1.	Petiole length (mm)
2.	Midrib length (mm)
3.	Lamina length (mm)
4.	Midrib : lamina length ratio
5.	Lamina width at widest point (mm)
6.	Lamina width : length ratio
7.	Lamina apex to widest point (mm)
8.	Lamina apex to widest point : length ratio
9.	Lamina apex angle (degree)
10.	Highest number of flower clusters per inflorescence
11.	Highest number of flowers per inflorescence
12.	Peduncle length (mm)
13.	Pedicle length (mm)
14.	Calyx height (mm)
15.	Calyx diameter (mm)
16.	Petal length (mm)
17.	Petal width at widest point (mm)
18.	Petal width : length ratio
19.	Petal apex to the widest point (mm)
20.	Petal apex to widest point : length ratio

results of phenetic analysis as the basis for segregating the South Australian population as a separate species.

Morphological characters were scored using ImageJ version 1.53a (https://imagej.net/ImageJ) on the images of the herbarium specimens on loan from AD, CANB and MEL and those held in NE (Appendix 1). A high-resolution image of the lectotype was obtained from G. Herbarium codes follow *Index Herbariorum* (http://sweetgum.nybg.org/science/ih/). We selected 26 specimens representing populations from South Australia, Victoria, and the border between south-eastern New South Wales and Victoria, which are currently referred to *Phebalium squamulosum* subsp. *squamulosum*. We also included specimens from the Sydney Basin, which is the typical form and the site of collection of the lectotype. Twenty vegetative and morphological characters, with 15 direct measurements and five ratios, were chosen based on Wilson (1970, 1998) and observations and experience of the authors (Table 1). All continuous values are an average of the three largest observations for leaves and well-developed parts (floral) for each specimen.

Principal component analysis was performed in R package 'ggplot2' (Wickham 2016) on two data sets, one with both vegetative and floral characters (23 specimens) after removal of specimens with missing data and the second one (26 specimens) with only vegetative characters.

Scanning electron microscope (SEM) micrographs of trichomes on lamina surfaces were taken using a JEOL JSM-6010LA Analytical SEM (JEOL Ltd., Tokyo). Images of seed were taken using a Nikon SMZ25. At least five specimens per taxon were examined for trichome variation. We had access to only a single seed from one specimen of South Australian population, however, we also examined the images of the seeds of this taxon available via the *Plants of South Australia* website (http://www.syzygium.xyz/saplants/Rutaceae/Phebalium/Phebalium_squamulosum_ssp._squamulosum.html). For the typical subspecies, we examined seeds from at least two specimens per population and for Victorian populations, seeds from more than five specimens were imaged and looked at.

The overall distribution of the new species is described using the Interim Biogeographic Regionalisation for Australia, version 7 (IBRA 7). Specimens from South Australia are cited following botanical regions of the state to facilitate their curation. The distribution of other specimens cited follow IBRA 7.

Results and discussion

We consider multiple lines of evidence to be generally desirable in delimiting species boundaries and describing it, but unnecessary when there is clear-cut morphological differences. Our phenetic analysis (Fig. 2) supports segregation of the South Australian taxon from the typical subspecies of the Sydney Basin (i.e. *Phebalium squamulosum* subsp. *squamulosum s.str.*) and the Victorian, Victoria-New South Wales border populations (hereafter referred as *P. squamulosum* subsp. *squamulosum s.lat.*). The principal component analysis of morphological data consistently retrieved three clusters, with South Australian specimens forming a tighter cluster compared with those of *P. squamulosum* subsp. *squamulosum s.lat.* and *P. squamulosum* subsp. *squamulosum s.str.* With c. 67% cumulative variations explained by the first three Principal Components (PC) (Fig. 2), we are confident that the clusters identified in this ordination reflect natural groups. The result from only vegetative data, with c. 83% cumulative variance explained by first three PCs, was very similar (ordinations result not presented).

Fig. 2. Results of Principal Component Analysis: *Phebalium calcicola* (black circles), *P. squamulosum* subsp. *squamulosum s.str.* (blue squares), populations of *P. squamulosum* subsp. *squamulosum s.lat.* from Victoria and the Victoria-New South Wales border region (brown triangles). **A** PC1 vs PC2; **B** PC1 vs PC3, based on morphological characters.

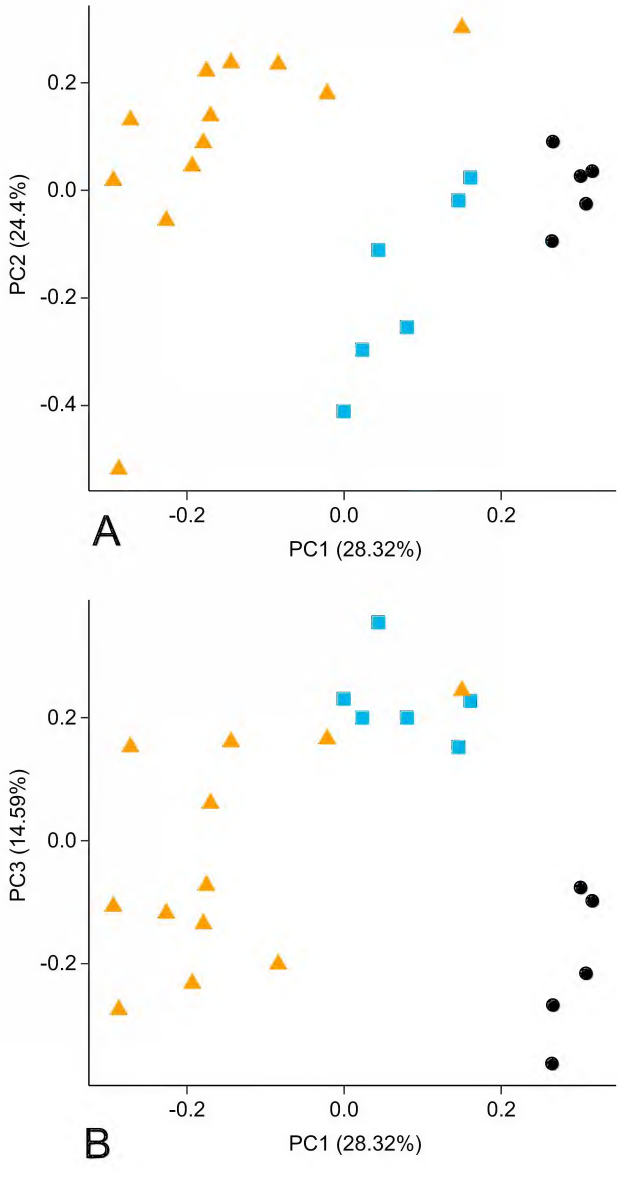

Table 2. Comparison of selected morphological attributes of *Phebalium calcicola* with *P. squamulosum* subsp. *squamulosum s.str.*

Character	*P. calcicola*	*P. squamulosum* subsp. *squamulosum s.str.*
Leaf lamina shape	oblong	elliptic
Leaf apex	truncate to emarginate, rarely rounded	obtuse, rarely rounded
Mucro on leaf apex	absent	present
Petiole length (mm)	0.5–1.5	0.5–4
Trichomes on adaxial lamina surface of immature leaf	stellate to lepidote	absent
Number of flowers on terminal inflorescence	up to 9 in single cluster, rarely in 2 clusters	12–15 (–22) in 3–5 clusters
Corolla colour	bright yellow	cream–light yellow
Seed coat ornamentation	discontinuous, longitudinal ridges	continuous longitudinal ridges

The difference in leaf lamina shape, reflected by ratio of lamina length to width and distance from apex to the widest point to lamina length, contributed the most in separating the South Australian population from the rest in our phenetic analysis. Comparative data on leaf apex (scored as apex angle in phenetic analysis), leaf trichome, corolla colour and seed ornamentations provided additional morphological evidence to recognise this South Australian population of *Phebalium*, currently treated as *P. squamulosum* subsp. *squamulosum*, as a distinct taxon (Table 2, Figs 3, 4 & 5).

The South Australian entity also differs from the geographically closest Victorian population of *Phebalium squamulosum* subsp. *squamulosum* in life form, vegetative and reproductive morphologies (S. Dema *et al.*, unpublished data), consistent with Wilson's (1970) observation of variation in Victorian populations. Three other subspecies of *P. squamulosum* occur in Victoria: subsp. *alpinum* (Benth.) Paul G.Wilson, subsp. *argenteum* Paul G.Wilson and subsp. *ozothamnoides* (F.Muell.) Paul G.Wilson (Duretto 1999; Wilson 2013). They also differ from *P. calcicola* in both morphology and habitat preference (S. Dema *et al.*, unpublished data).

We recognize the South Australian entity at species rank rather than as a subspecies of *P. squamulosum*, as our concept of species aligns with that of the unified species concept proposed by de Queiroz (2005: 205), where species are "separately evolving segments of population level lineages" and properties such as "phenetic distinguishability" and "ecological differences" are evidences of a lineage separation. Furthermore, this South Australian taxon differs from the typical subspecies and *P. squamulosum* subsp. *squamulosum s.lat.* in more than "two persistent good characters" and there are no "intermediate population[s]" to "demonstrate continuity of character states" to be assigned a subspecies rank (cf. Forster 2003: 437; Bruyns 2002).

Currently, there are only four other species of *Phebalium* known from South Australia, and they are morphologically very distinct from the new species described here. We provide a modified key to all taxa of *Phebalium* in South Australia.

Taxonomy

Phebalium calcicola S.Dema & I.Telford, *sp. nov.*

Holotypus: South Australia, South-Eastern: [precise locality withheld for conservation reasons] E of Kongorong, 6 Nov. 2019, *S. Dema 422, D.J. Duval, D.E. Murfet & T.S. Te* (AD). **Isotypi:** BRI, CANB, K, MEL, MO, NE109849, NSW [*distribuendi*]. Fig. 6.

The type gathering is from two plants. The population is very small and morphologically homogeneous.

Key to *Phebalium* in South Australia

1. Leaf closely revolute
- **2.** Calyx truncate to undulate; pedicels slender . . . . . *P. stenophyllum*
- **2:** Calyx definitely 5-toothed; pedicels thick . . . . . *P. lowanense*

1: Leaf not closely revolute, though margin may be recurved
- **3.** Leaf upper surface and margin smooth . . . . . ***P. calcicola***
- **3:** Leaf upper surface and/or margin glandular-warty
  - **4.** Leaf margin only glandular-warty, upper leaf surface smooth; midrib sunken on the upper surface . . . . . *P. bullatum*
  - **4:** Leaf upper surface, incl. margin glandular-warty; midrib not sunken . . *P. glandulosum* subsp. *macrocalyx*

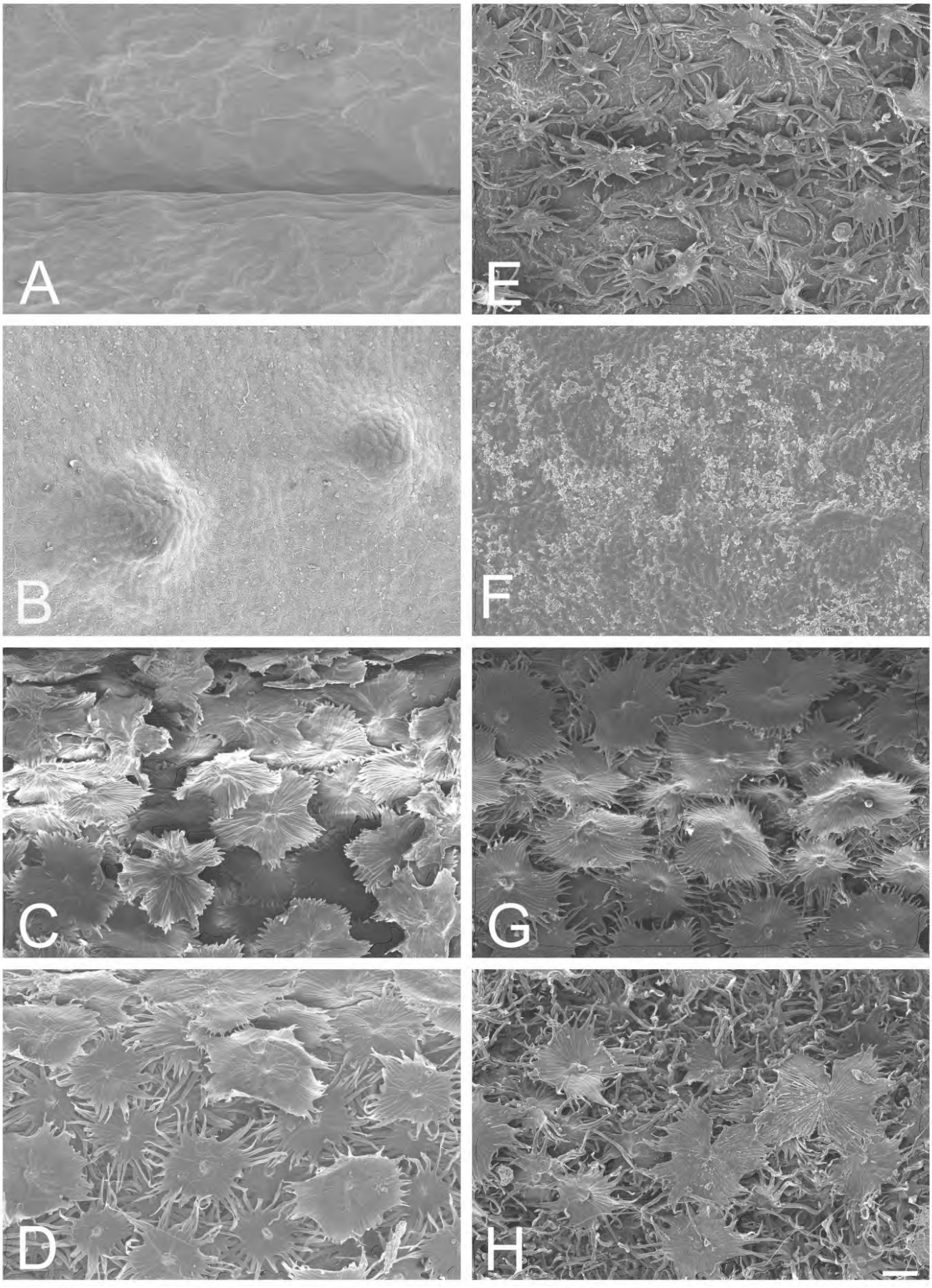

Fig. 3. Lamina surface of *Phebalium squamulosum* subsp. *squamulosum s.str.* (**A–D**) and *P. calcicola* (**E–H**). **A**, **E** Immature adaxial surface; **B**, **F** mature adaxial surface; **C**, **G** immature abaxial surface; **D**, **H** mature abaxial surface. — A–D *S. Dema 367* (NE109511); E–H *D.N. Kraehenbuehl 2787* (AD97839121). Scale bar = 0.1 mm. Images: S. Dema.

Phebalium squamulosum subsp. *squamulosum auct. non.* Vent., *pro parte*, excluding all populations other than that from south-eastern South Australia: Jessop, *J. Adelaide Bot. Gard.* 12: 60 (1989); W.R.Barker *et al.*, *J. Adelaide Bot. Gard. Suppl.* 1: 87 (2005); T.Te *et al.*, *Ex Situ Conservation Threat. S. Austral. Pl.* 105–107 (2009); S.Gillam & R.Urban, *Regional Spp. Conservation Assessm. Proj., Phase 1 Rep.: S.E. Reg.* (2011).

Shrub erect, multi-stemmed, to 2 m tall. *Bark* ± smooth, grey to reddish brown with paler horizontal lenticels. *Branchlets* greyish green, rarely sparsely glandular, covered with silvery lepidote hairs when young, branchlets becoming reddish brown and glabrescent with age. *Leaves* alternate, exstipulate, simple; petiole 0.5–1.5 mm long, with silvery lepidote hairs; lamina oblong, slightly broader towards base, 8.6–14 mm

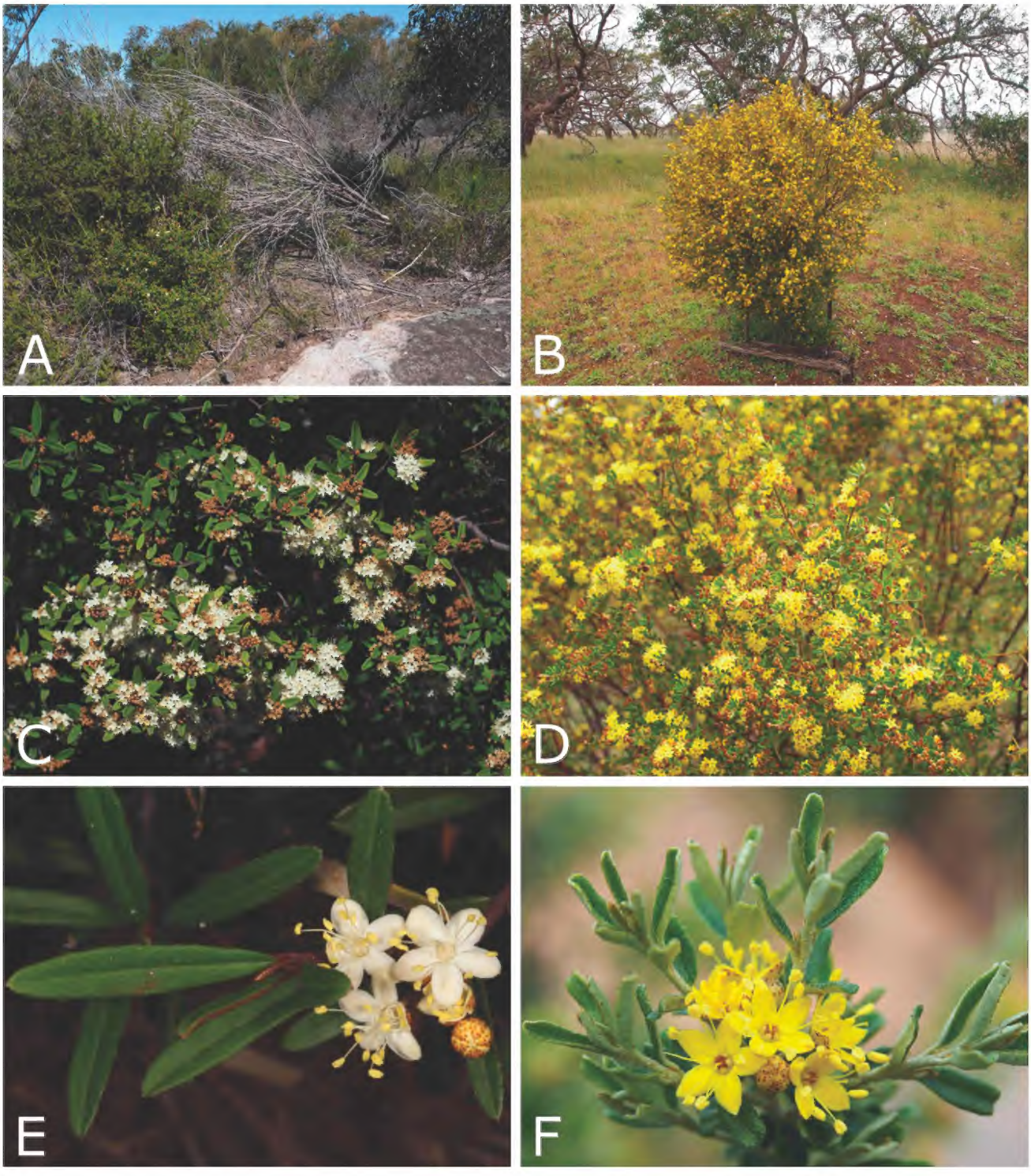

Fig. 4. Comparison of *Phebalium squamulosum* subsp. *squamulosum s.str.* (**A**, **C**, **E**) and *P. calcicola* (**B**, **D**, **F**). **A**, **B** Habitat and habit; **C**, **D** flowering branches; **E**, **F** flowering shoot. — A, C Ku-ring-gai Chase National Park, *S. Dema 367* (NE); E Ku-ring-gai Chase National Park, *J.J. Bruhl 3527* (NE); B, D, F type locality, *S. Dema et al. 422*. Photos: A, C, E: J.J. Bruhl; B, D, F: D.J. Duval.

long, 2.5–4.5 mm wide; apex truncate to emarginate, rarely rounded, muticous; base rounded; margin entire, recurved; midrib on adaxial (upper) surface deeply impressed towards base only; abaxial (lower) surface with silvery (rufous) stellate to lepidote trichomes; adaxial surface with stellate to lepidote trichomes on immature leaves, with age glabrescent to sparsely scabridulous with remnant base of trichomes; *oil glands* on adaxial lamina surface not prominently raised. *Inflorescence* terminal, of a single (double) (4–) 6–9 flowered umbel, ± sessile, densely silvery and rufous lepidote. *Calyx* shallowly cup-shaped, 0.5–1.2 mm long, 1.9–2.8 mm wide; abaxial surface with silvery to rufous lepidote trichomes; margin truncate. *Corolla* of 5 (6) free petals; petals ovate, 2.3–3.2 mm long, 1.4–2.3 mm wide, shortly acuminate; abaxial surface densely silvery towards base, rufous-lepidote towards apex; adaxial surface glabrous, bright yellow. *Stamens* 10; filaments filiform, 2.4–4.5 mm long, glabrous; anthers oblong to elliptic, 0.6–1.4 mm long; apical gland minute, subglobose. *Ovary* subglobose, silvery-lepidote; style 3.5–4 mm long, terete, glabrous; stigma minutely capitate. *Fruit* a capsular schizocarp of up to 5 erect cocci; cocci ovoid; seed oblong to ovoid, c. 2 mm long, c. 1.2 mm wide, with up to nine discontinuous longitudinal ridges, dark grey to black. **Figs 3E–H, 4B, D, F, 5A, 6.**

Distribution and habitat. *Phebalium calcicola* is restricted to the Naracoorte Coastal Plain Bioregion of south-eastern South Australia, south-west of the regional city Mount Gambier, in the vicinity of Mount Schank and Kongorong (Fig. 1). It grows on shallow, reddish sandy loam over limestone pavements (calcrete) in *Eucalyptus baxteri* low open woodland. Associated species recorded include **Scabiosa atropurpurea*, *Swainsona lessertiifolia*, *Clematis microphylla*, *Dianella brevicaulis*, *Austrostipa* sp. and *Poa poiformis* subsp. *poiformis*.

Phenology. Flowers late Sep.–Nov.; fruits Dec.–Feb.

Diagnostic characters. The species differs from *P. squamulosum* subsp. *squamulosum s.str.* in its leaf lamina shape (oblong in *P. calcicola* vs elliptic in subsp. *squamulosum s.str.*), leaf apex (without a mucro vs with a mucro), indumentum of adaxial lamina surface of immature leaves (with stellate to lepidote trichomes vs glabrous), corolla colour (bright yellow vs cream, rarely light yellow) and seed coat ornamentation (discontinuous longitudinal ridges vs continuous longitudinal ridges) (Table 2, Figs 3–6).

Phebalium calcicola can be distinguished from the geographically closest populations of *P. squamulosum* Vent. subsp. *squamulosum s.lat.* in Victoria in life form (always shrub in *P. calcicola* vs shrub to small tree), leaf shape (oblong vs narrowly elliptic or broadly linear or narrowly obovate), mid rib on abaxial surface (prominently raised towards leaf base only vs prominently raised throughout) and calyx margin (truncate vs broadly and shallowly toothed) (S. Dema *et al.*, unpublished data).

Conservation Status. Extremely rare, currently known from a single locality with only three extant wild plants and c. 25 individuals propagated from the three original plants, which have been planted in the past ten years (Drew Laslett, pers. comm., 17 Dec. 2020). Listed as Endangered under the *National Parks and Wildlife Act 1972* (South Australia).

Phebalium calcicola qualifies as a 'wild' population to be assessed following International Union for Conservation of Nature (IUCN) guidelines (IUCN 2019): it is a distinct species with only one known population and currently 'lightly managed' to protect it from herbivory and encourage natural recruitment. With the observed threat from weed and herbivory, exacerbated by extremely few wild plants, population size of <50 individuals and an area of occupancy <1 km, *P. calcicola* meets the criteria for listing as Critically Endangered based on IUCN criteria B2 (a, b) and C2 (a: ii) and our assessment supports that of Gillam & Urban (2011) and DEWNR (2016). We recommend nomination of this taxon for listing under the *Environment Protection and Biodiversity Conservation Act 1999*.

Fig. 5. Seeds of *Phebalium calcicola* (**A**) and *P. squamulosum* subsp. *squamulosum s.str.* (**B**). Left: side view; right: hilum view. — A *D.J. Duval 1709* (AD232323); B *A.E. Orme 671* (NE108649). Scale bar = 200 µm. Images: S. Dema.

N.C.W. BEADLE HERBARIUM
NE 109849
UNIV. OF NEW ENGLAND AUSTRALIA
N.C.W. Beadle Herbarium (NE)
University of New England
ISOTYPE
Phebalium calcicola S.Dema & I.Telford
Det.: S.Dema 27 NOV 2020
N.C.W. Beadle Herbarium (NE)
University of New England
Armidale, NSW 2351, Australia
Notice of change of determination would be appreciated by NE.
NE 109849
Rutaceae
Phebalium squamulosum Vent. s. lat.
AUSTRALIA: South Australia: South-Eastern:
[Precise location withheld for conservation reasons]
Flat. Red brown loam over limestone. Eucalyptus obliqua open woodland with Scabiosa atropurpurea, Clematis, Scaevola, Dianella.
8 plants at site. Multi-stemmed shrub up to 2 m. Corolla bright yellow. Petals usually 5, rarely 6.
Cuttings, Phytochem, Si gel, Spirit.
Coll.: S. Dema 422 06 Nov 2019
D.J. Duval, D.E. Murfet, T.S. Te
Det.: S. Dema (NE) 06 Nov 2019
Reps: AD, BRI, CANB, K, MEL, MO, NSW
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NE Digital Image 12 Nov 2020
NE Digital Image 27 May 2021

Fig. 6. Isotype of *Phebalium calcicola*: *S. Dema et al. 422* (NE109849). Precise location withheld for conservation reasons.

The South Australian Seed Conservation Centre at the Adelaide Botanic Gardens has initiated management and monitoring of this taxon by establishment of exclusion fences, propagation and planting. This taxon is also conserved ex-situ with seeds banked at the Seed Conservation Centre. However, further efforts are required to explore for additional populations to reduce the risk of extinction of the species in the wild.

Etymology. From the Latin *calx* (limestone) and *-cola* (-dweller), referring to the habitat of this species. The epithet is treated as a noun in apposition; it has the same ending regardless of the gender of the genus name (Stearn 2004).

Notes. Specimens cited below are from the type locality, except *D.N. Kraehenbuehl 2787*, which appears to be from a different site, which no longer has an extant population. It is likely that the *Phebalium* cultivated and available from plant nurseries under the trade name 'Dulcie's Delight' is *P. calcicola* (Barrie 2005). We will test this hypothesis using molecular data.

Additional specimens examined [precise localities withheld for conservation reasons]

SOUTH AUSTRALIA. **South-Eastern:** W of Mount Schank, SSW of Mount Gambier, 28 Sep. 1978, *P. Copley 333* (AD); Hundred of Port MacDonnell, 20 Sep. 2007, *D.J. Duval 961, T.S. Croft & C. Brodie* (AD); E of Kongorong, 10 Dec. 2009, *D.J. Duval 1709, M.J. Thorpe & D.E. Symon* (AD); Mt Gambier region, 20 Sep. 1975, *M. Kenny s.n.* (AD99133205); Between Yahl and Mount Schank, 25 Aug. 1976, *D.N. Kraehenbuehl 2787* (AD); Hundred of Port MacDonnell, 20 Nov. 1993, *D.N. Kraehenbuehl 6105* (AD); Hundred of MacDonnell, ESE of Kongorong, 1 Oct. 1976, *D. Rowley 77* (AD).

Acknowledgements

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Appendix 1. List of specimens used in the phenetic analysis.

Voucher	Locality
Phebalium squamulosum* subsp. *squamulosum s.str.	
S. Dema 366 (NE109510)	N.S.W.: Sydney Basin, Terrey Hills, Mona Vale Road
S. Dema 367 (NE109511)	N.S.W.: Sydney Basin, Ku-Ring-Gai Chase National Park, Guringai Land Aboriginal Engraving Site
B.G. Briggs s.n. (NE4203)	N.S.W.: Sydney Basin, Belrose, near Frenchs Forest
E.F. Constable s.n. (NE10882)	N.S.W.: Sydney Basin, Central Colo, N of Windsor
C. Burgess s.n. (NE22625)	N.S.W.: Sydney Basin, Wheeney Creek, near Kurrajong
J.J.H. de Labillardière s.n. (G00340116)	Habitat in N. S. Walles
Phebalium squamulosum* subsp. *squamulosum s.lat.	
D.E. Albrecht 3635 (CBG8906150.1)	Vic.: South East Corner, c. 2 km SE of Mt Carlyle summit
D.E. Albrecht 4830 (CBG9217320.1)	Vic.: South East Corner, Allen Head, Genoa River, Bottom Lake
P. Carmen 342 (CANB764607.1)	N.S.W.: South East Corner, Mogendoura Mountain, off 'K' Ridge Road
S. Dema 416 (NE109574)	Vic.: Eastern Highlands, Croajingolong National Park, Genoa Falls, S bank of Genoa Creek, along the track
S. Dema 417 (NE109575)	Vic.: Eastern Highlands, Croajingolong National Park, along Genoa Peak Walking Track
S.J. Forbes 2938 (MEL1557395)	Vic.: South East Corner, Genoa Creek falls, ca 3 km W of Genoa
J.R. Nevin 165 (NE108084)	Vic.: Eastern Highlands, 9.8 km SE of Healesville, 5.8 km E of Badgers Creek along Donna Buang Rd
S. Dema 414 (NE109572)	Vic.: Eastern Highlands, c. 12 km N of Noojee, Skerry Creek Road, below a plantation clearing
J.J. Bruhl 3576 (NE107627)	Cultivated: Royal Botanic Gardens Melbourne ex "Garden Origin"
N.G. Walsh 3273 (MEL2013532)	Vic.: South Eastern Highlands, East Beenak, Bunyip Valley Road, c. 2 km ESE from Tomahawk Gap
N.G. Walsh 1495 (MEL540264)	Vic.: South Eastern Highlands, Ben Cairn Rd, 300 m W from its crossing of Don River, 7 km due W from Mt Donna Buang
P.R.H. St John s.n. (MEL0005107)	Vic.: South Eastern Highlands, about 4 miles (east) from Yarra Junction Station
P.K. Gullan s.n. (MEL0599641A)	Vic.: South Eastern Highlands, Donna Buang-Healesville Rd, approx. 0.5 km S of Myrtle Crk crossing, 1.5 km due NW of Ben Cairn
S. Dema 415 (NE109573)	Vic.: South East Corner, Tambo River, W side of Moonlight Road
T.S. Hart s.n. (MEL5056A)	Vic.: South East Coastal Plain, Bairnsdale
Phebalium calcicola	
S. Dema 422 (NE109849)	(See *Specimens examined* for details)
D.N. Kraehenbuehl 2787 (AD97839121)	
P. Copley 333 (AD97850350)	
D.N. Kraehenbuehl 6105 (AD99445013)	
D. Rowley 77 (AD99706184)	

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Ptilotus crinitus (Amaranthaceae), a new species from Western Australia's Kimberley region

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Abstract: Evaluation of a specimen of *Ptilotus* R.Br. (Amaranthaceae), collected from a remote location in the northern Kimberley, reveals it to be a unique taxonomic entity. The morphological differences between this entity and its closest relatives *P. distans* (R.Br.) Poir. and *P. capensis* (Benl) A.R.Bean are discussed and found to support its recognition as the new species *Ptilotus crinitus* T.Hammer & R.W.Davis. An identification key is given for the three species.

Keywords: Amaranthaceae, new species, *Ptilotus*, taxonomy, Western Australia

Introduction

Ptilotus R.Br. (Amaranthaceae) encompasses approximately 125 species with most of the taxonomic diversity within the genus occurring in arid or semi-arid Australia, particularly in Western Australia's Eremaean province (Hammer *et al.* 2018, 2019b). Smaller numbers of species are native to monsoonal northern Australia or temperate southern Australia.

Ptilotus distans (R.Br.) Poir. is a species endemic to northern Australia, occurring mainly in the north of the Northern Territory (i.e. the 'Top End') and with three records (*K.F. Kenneally 11109*, PERTH01647946; *M.D. Barrett MDB 4917*, PERTH09302077; *R.L. Barrett 737*, PERTH06606806) from the Kimberley, Western Australia. *Ptilotus distans* is a member of a species group with *P. fusiformis* (R.Br.) Poir., *P. xerophilus* T.Hammer & R.W.Davis and *P. polystachyus* (Gaudich.) F.Muell. (i.e. the *P. fusiformis* species group). These species together with five others form a well-supported subclade of what has been informally referred to as 'Clade D' (Hammer *et al.* 2019a). Some typical characters within the subclade are an herbaceous habit, greenish flowers (sometimes tinged pink) that are presumably moth-pollinated (e.g. some have nocturnal anthesis, see Hammer *et al.* 2019a), and with the typically five fertile stamens commonly reduced to four, plus one inconspicuous staminode.

Benl (1984) described *P. distans* subsp. *capensis* Benl from the York Peninsula, Queensland. He differentiated this subspecies from typical *P. distans* (i.e. in the Northern Territory) based on staminal filament and style lengths and differences in the indumentum on the bracts, staminal cup and ovary. Bean (2008) considered the differences between these two subspecies to be significant enough to warrant them to be recognised as distinct species, so he raised Benl's taxon to species rank as *P. capensis* (Benl) A.R.Bean.

The present study evaluates the morphology of a specimen that was collected from a remote coastal area in the northern Kimberley, Western Australia and initially identified as *Ptilotus* aff. *distans* (referred to below as *Ptilotus crinitus*).

Methods

This study was based on examination of dried specimens of *Ptilotus* housed at PERTH and AD.

Results and discussion

Within the genus, the new species *Ptilotus crinitus* is most similar to *P. distans* but can be segregated by its habit, bract shape and size, and sepal indumentum.

Ptilotus crinitus is quite different in habit to *Ptilotus distans* and *P. capensis*. These species are few-branched, narrow and erect tuberous herbs, 0.3–1 m high (e.g. see specimens, K000356752 and K000356753, available at https://plants.jstor.org/stable/10.5555/al.ap.specimen.k000356752). The new species is a rounded herb or subshrub with lateral ascending branches to 40 cm high with numerous branches (Fig. 1). Unfortunately, neither the root system nor the base of the plant was collected, and a measurement as to the width of the whole plant was not recorded.

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Key to species

1. Rounded and ascending much-branched herbs or subshrubs to 0.4 m high; bract <1 mm wide; abaxial sepal indumentum with hairs to c. 8 mm long, exceeding the sepal apices by 1–2 mm . . . ***Ptilotus crinitus***

1: Erect little-branched herbs to 1 m high; bract ≥ 1.5 mm wide; abaxial sepal indumentum with hairs to c. 4 mm long, shorter than or equal to the sepal apices

2. Bract ovate, <4 mm long; style <3.5 mm long . . . . . ***Ptilotus distans***

2: Bract narrowly lanceolate, >5 mm long; style >5 mm long . . . . . ***Ptilotus capensis***

The bracts of *P. crinitus* are similar to *P. capensis* in being narrowly lanceolate but are much shorter (2.9–3.2 mm) and narrower (0.7–0.9 mm) than those of *P. capensis* (c. 5.2 mm long and c. 1.5 mm wide). The bracts of *Ptilotus distans* differ in shape to the other two species, being ovate, and are much wider than *P. crinitus* at 1.6–2 mm wide. *Ptilotus distans* has a bract length of 2.3–3.8 mm long, similar to *P. crinitus*.

The hairs on the outer surface of the sepals of *P. crinitus* are up to 8 mm long and extend beyond the sepal apex by 1–2 mm (Fig. 2D). Sepal hairs in *P. capensis* and *P. distans* are at most half of the length (to 4 mm long) and do not extend beyond the sepal apex (Fig. 2B). The sepals of *P. crinitus* are more finely tapering than those of *P. distans* (especially the inner three), so much so that the apex is more or less obscured within the hairs that surpass it (Fig. 2A, D).

We find that the differences in these characters are sufficient to recognise the new entity at species rank, and therefore we formally describe it below as *Ptilotus crinitus* T.Hammer & R.W.Davis.

Taxonomy

Ptilotus crinitus T.Hammer & R.W.Davis, ***sp. nov.***

> **Holotypus:** North Kimberley, Western Australia [precise locality withheld for conservation reasons], 6 Feb. 2008, *G.J. Keighery & M.N. Lyons KIBS 1188* (PERTH09170898). **Isotypi:** CANB, DNA [to be distributed].

Rounded and ascending *perennial herbs* or *subshrubs* 30–40 cm high, numerous branches. *Stems* spreading and ascending, angled, ribbed, glabrous or with very sparse hairs. *Leaves* narrowly lanceolate to narrowly elliptical, 5–20 mm long, 0.4–0.8 mm wide, glabrous; base sessile; margins entire; apex acute. *Inflorescences* terminal, spiciform, interrupted, 3–10 cm long, <10-flowered, flowers spaced 1–2 cm apart. *Bracts* narrowly lanceolate, 2.9–3.2 mm long, 0.7–0.9 mm wide, translucent, central portion with a few sparse thickened hairs to c. 0.2 mm long; midrib darkened; apex acute. *Bracteoles* narrowly ovate, uneven in size, 5.5–7.0 mm long, 2.9–3.1 mm wide, opaque, straw-coloured, glabrous or with a few sparse fine hairs to c. 0.5 mm long; midrib prominent, pinkish; apex acute. *Outer sepals* narrowly lanceolate, 12.0–13.0 mm long, 1.4–1.5 mm wide at the base; adaxial surface glabrous, tinged pale pink; abaxial surface with sub-verticillate hairs to 8 mm long that exceed the sepal apex by 1.0–2.0 mm; apex very narrowly attenuate. *Inner sepals* narrowly lanceolate, 11.5–12.0 mm long, 1.4–1.5 mm wide at the base; adaxial surface with a few fine hairs on the margin, tinged pale pink; abaxial surface with sub-verticillate hairs to 8 mm long that exceed the sepal apex by 1.0–2.0 mm; apex very narrowly attenuate. *Fertile stamens* 3; *filaments* uneven in length, 2.5–3.0 mm long, with silky hairs c. 0.5 mm long on the dilated base; *anthers* 0.9–1.0 mm long, 0.2–0.3 mm wide. *Staminodes* 2, 1.3–1.5 mm long. *Staminal cup* 0.4–0.6 mm long, symmetrical, lacking appendages, with long fine silky hairs to c. 1.5 mm long. *Ovary* ovoid, 1.8–2.0 mm long, 1.3–1.5 mm wide, with silky hairs to c. 0.8 mm long on the apical ½ of the ovary surface; *stipe* very short and flattened, 0.1–0.2 mm long. *Style* slightly to distinctly curved, 2.0–2.5 mm long, slightly excentric on the ovary apex. *Stigma* unlobed, distinctly capitate. *Seeds* not seen. **Figs 1, 2D–F.**

Diagnostic features. *Ptilotus crinitus* can be distinguished from all other members of the genus by the combination of being a perennial herb or subshrub to c. 40 cm high and having narrowly lanceolate to narrowly elliptical glabrous leaves <0.9 mm wide, interrupted inflorescences with flowers spaced flowers 1–2 cm apart, narrowly lanceolate bracts 2.9–3.2 mm long and 0.7–0.9 mm wide, hairs on the abaxial surface of the sepals to 8 mm long and exceeding the sepal apex by 1–2 mm, a staminal cup with long silky hairs, and an ovary with long silky hairs (to c. 0.8 mm long) on the distal half.

Phenology. Flowers recorded for February, probably January to April.

Distribution and habitat. *Ptilotus crinitus* is only known from one record in northern Kimberley, where it was collected near the beach on shallow sand over sandstone and in a low open eucalypt woodland over tussock grassland.

Conservation status. *Ptilotus crinitus* is currently only known from a single location in the remote northern Kimberley, Western Australia. We therefore recommend that this taxon be listed as Priority One under the Conservation Codes of Western Australian Flora (Smith & Jones 2021).

Proposed vernacular name. Long-haired mulla mulla.

Etymology. The specific epithet is from Latin for "long-haired", which refers to the hairs on the abaxial surface of the sepals that exceed the sepal apex.

Taxonomic Notes. Flowers on *P. crinitus* were found to have three fertile stamens and two staminodes. Four fertile stamens and one staminode are typical for all other species in the *P. fusiformis* species group, including for *P. distans* and *P. capensis*. Benl (1984), reported *P. distans* subsp. *capensis* to have typically four fertile stamens, but found it to rarely have five or three. Fertile stamen number is usually consistent within *Ptilotus* species, except with a few notable cases (e.g. *P. manglesii* (Lindl.) F.Muell.; see Hammer 2020). It may be that

Fig. 1. Scan of the holotype of *P. crinitus* (*G.J. Keighery & M.N. Lyons KIBS 1188*; PERTH 09170898).

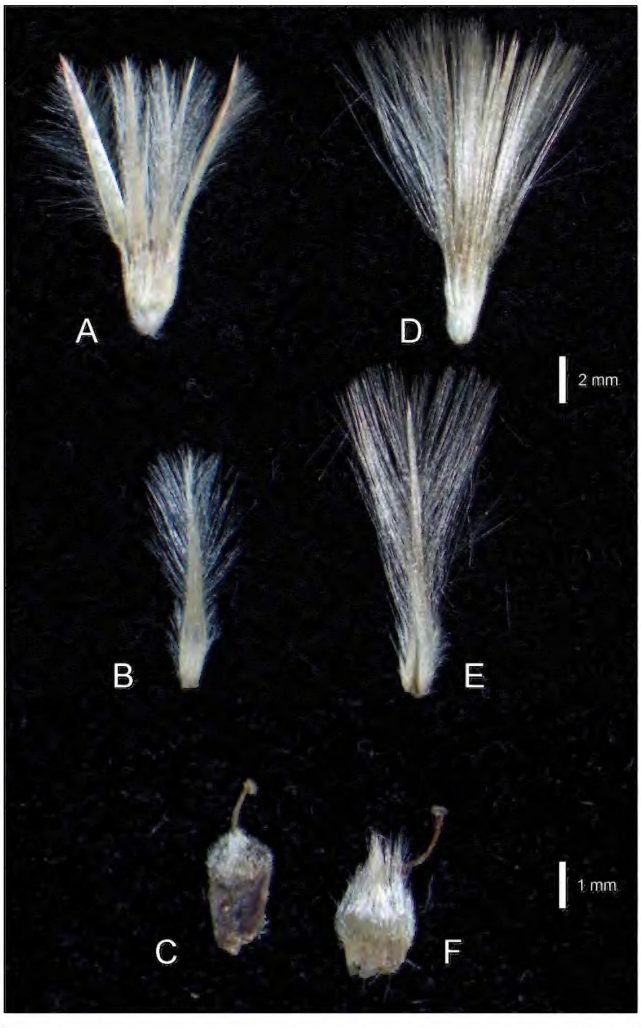

Fig. 2. Composite image comparing the indumentum between *P. distans* (**A–C**) and *P. crinitus* (**D–F**): whole flower (A, D), outer sepal (B, E) and ovary (C, F). — A–C *K.F. Keneally 11109* (PERTH01647946), D–F *G.J. Keighery & M.N. Lyons KIBS 1188* (PERTH09170898). Note: Separate scales were used for the flowers and sepals (A, B, D, E; scale bar = 2 mm) versus the ovaries (C, F; scale bar = 1 mm).

having three fertile stamens is typical for *P. crinitus* or it could vary in number like in *P. capensis*.

Benl (1984) described the ovary indumentum of *P. distans* subsp. *distans* as being shortly pubescent in the upper half with simple hairs, 0.2–0.3 mm long, and the ovary indumentum of *P. capensis* consisting of articulate hairs to 2.4 mm long. This is in contrast to Bean (2008), who described the hairs on the ovary of *P. distans* to be pubescent, non-articulate and to 1.4 mm long and the ovary hairs of *P. capensis* to 3.3 mm long. Our examinations of *P. distans* specimens at PERTH and AD only found ovary hairs of the type described by Benl (i.e pubescent and 0.2–0.3 mm long). We found that *P. crinitus* had silky and articulate hairs on the ovary to c. 0.8 mm long, which are noticeably longer and of a different texture than those typical of *P. distans* (Fig. 2C, F). Since we could not confirm the indumentum characters described by Bean (2008), we believe that ovary indumentum may be an additional difference between *P. crinitus* and *P. distans*, at least for most morphotypes of *P. distans*.

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Gomphrena axillaris and *G. longistyla* (Amaranthaceae), new species of *Gomphrena* from central and northern Australia

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Abstract: Two species of *Gomphrena* L. (Amaranthaceae) are here described as new, *G. axillaris* R.W.Davis & J.Palmer and *G. longistyla* R.W.Davis, J.Palmer & T.Hammer. *Gomphrena longistyla* occurs in the northern Kimberley region of Western Australia, and *G. axillaris* is distributed across the arid interior of Northern Territory, Western Australia and Queensland. Modifications are provided to the previously published species key to Australian *Gomphrena* species to enable identification of the two new species.

Keywords: Amaranthaceae, Australia, new species, *Gomphrena*, taxonomy

Introduction

Gomphrena L. is one of the largest genera in Amaranthaceae, with approximately 120 species native to tropical and subtropical North America, South America and Australia (Müller & Borsch 2005; Townsend 1993). In Australia, there are currently 32 endemic species, which occur in northern arid and monsoonal parts of the Northern Territory, Queensland, South Australia and Western Australia (Palmer 1998). *Gomphrena celosioides* Mart. is naturalised in all states and territories of mainland Australia. The highest species diversity occurs in the Northern Territory and Western Australia, with 23 and 20 native species, respectively. Additionally, three phrase-named taxa are currently listed on the national census (APC 2020) and one phrase-named taxon in FloraBase (Western Australian Herbarium 1998–). The present study formally describes three of these phrase-names as two distinct species: *G.* sp. Cambridge Gulf (*K.F. Kenneally 11899 K*) from the Kimberley region of Western Australia as *G. longistyla* R.W.Davis, J.Palmer & T.Hammer and *G.* sp. Martins Well (*K.F. Kenneally 6116*) from arid Northern Territory and Western Australia, as well as *G.* sp. Doongmabulla (*E.J.Thompson+ GAL137*) from Queensland as *G. axillaris* R.W.Davis & J.Palmer.

Material and Methods

This study is based on the examination of dried specimens housed at PERTH and CANB, including specimens on loan to CANB from AD, BRI, MEL, NT and PERTH. The terminology used in this study follows Palmer (1998), with two notable exceptions.

The first exception is the replacement of the term 'tepals' with 'sepals', due to recent studies (e.g. Ronse De Craene 2013; Vrijdaghs *et al.* 2014) showing the perianth of Amaranthaceae, among other families within the Caryophyllales, being unambiguously of calycine origin. Taxonomic studies of other genera within subfamily Gomphrenoideae and other clades within the family (e.g. *Ptilotus* R.Br.) have recently adopted this change in terminology for the perianth of Amaranthaceae (Borsch *et al.* 2018; Hammer *et al.* 2019; Sánchez-del Pino *et al.* 2019). Secondly, Palmer (1998) described the staminal filaments as united around the ovary in a tube or cup and the projections on the tube that alternate with the stamens as 'pseudostaminodes'. This study follows the terminology of Sánchez-del Pino *et al.* (2019) in describing this tube-like structure as an 'androecial tube' and associated appendages as 'androecial tube appendages'.

Taxonomy

Gomphrena longistyla R.W.Davis, J.Palmer & T.Hammer, *sp. nov.*

Holotypus: [precise locality withheld for conservation reasons] Kununurra, Western Australia, 30 Jan. 2008, *G. Byrne 3025* (PERTH08098131). **Isotypus:** CANB.

Gomphrena sp. Cambridge Gulf (*K.F. Kenneally 11899 K*) Western Australian Herbarium, *FloraBase* https://florabase.dbca.wa.gov.au/ [accessed: 13 February 2020].

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Modified key to *Gomphrena* in Australia

Couplets 14–17 and 21–22 of the key provided by Palmer (1998) require modifications as follows.

14. Androecial tube shorter than fruit

17. Androecial tube appendages present, much shorter than staminal filaments

17a. Bracteoles 1.8–3.5 mm long; sepals c. equal in length, 1.6–2.8 mm long; style to 1 mm long, not exceeding sepal apex . . . . . ***Gomphrena leptophylla***

17a: Bracteoles 3.0–4.5 mm long; sepals unequal, outer 3 sepals 2.8–4.6 mm long; style >2 mm long exceeding sepal apex . . . . . ***Gomphrena longistyla***

17: Androecial tube appendages absent

21: Spikes 5–9 mm wide; sepals up to 3.4 mm long

22. Bracteoles distinctly shorter than sepals, translucent throughout, style 0.7–0.9 mm long . . ***Gomphrena conica***

22: Bracteoles equal to or slightly longer or shorter than sepals

22a. Bracteoles opaque white for half their length or at apex only; style 0.3–0.9 mm long, stigma 0.2–0.5 mm long . . . . . ***Gomphrena sordida***

22a: Bracteoles translucent or rarely opaque for one third of length; style 0.1–0.5 mm long, stigma 0.05–0.2 mm long . . . . . ***Gomphrena axillaris***

Annual herb, open or semi-erect to erect, (7–) 10–30 cm high, up to c. 40 cm wide, appearing multi-stemmed at ground level. *Stems* terete, with sparse, soft, spreading or crimped, hairs, glabrescent. *Leaves* cauline, sessile, narrowly obovate to elliptic or linear, (11–) 15–65 mm long, 1–4 mm wide; upper surface glabrous or with sparse, soft, spreading hairs, lower surface glabrous or with sparse, soft, spreading hairs. *Inflorescence* terminal, pedunculate or rarely sessile, solitary, globose to ovoid to cylindrical, pink, (6–) 8–15 (–20) mm long, 6–12 mm wide, elongating as mature flowers fall. *Bracts* broadly ovate, persistent after flowers shed, 1.8–2.8 mm long, 1.4–2.0 mm wide, sessile to subsessile, entire, glabrous, white opaque for up to half of length; mid-nerve faint. *Bracteoles* narrowly ovate to ovate, falling with flowers, 3.0–4.5 mm long, 1.0–2.5 mm wide, slightly shorter than sepals, white opaque up to two thirds of length, entire, glabrous, acute; mid-nerve faint. *Sepals* 5; *outer sepals* 3, oblong to slightly narrowly ovate, pink or mauve, 2.8–4.6 mm long, 0.7–1.1 mm wide; margin entire; apex broadly acute to rounded, entire; mid-nerve terminating before sepal apex; outer surface with dense white or pale brown, tangled, woolly hairs, covering the lower half of the sepals or to the end of the sepal mid-nerve; inner surface glabrous; *inner sepals* 2, narrowly obovate, pink or mauve, smaller than outer sepals, 2.2–4.3 mm long, 0.4–1.0 mm wide; margin entire; apex acute, entire; mid-nerve terminating before sepal apex; outer surface with dense white or pale brown, tangled, woolly hairs, covering the lower half of the sepals or to the end of the sepal mid-nerve; inner surface glabrous. *Stamens* 5, 2.3–4.0 mm long; *androecial tube* pink, shorter than fruit, 0.5–1.1 mm long; *androecial tube appendages* present, shorter than filaments; apex truncate, acute or toothed; *filaments* pink, 1.1–3.0 mm long, apex apiculate; anthers 0.6–1.1 mm long, yellow-orange. *Style* 2.0–2.6 mm long, pink; stigma 0.1–0.3 mm long. *Fruit* ovoid, pink, 1.0–1.5 mm long, 0.8–1.2 mm wide. *Seed* compressed, ovoid, brown, 0.9–1.3 mm long, 0.9-1 mm wide. **Fig. 1.**

Diagnostic characters. *Gomphrena longistyla* differs from all other Australian species in the genus in being a lax, open, herb with bright pink ovoid to cylindrical spikes to 12 mm wide, androecial tube shorter than fruit, androecial tube appendages present, staminal filaments to 3.0 mm long, and style to 2.6 mm long, exerted well beyond sepal apex.

Phenology. Collections suggest flowering dates are varied, with the majority collected in the wet season, December, January and February, however, other collections have been made in March, April, June, July and August.

Distribution and habitat. *Gomphrena longistyla* is currently known only from the Cambridge Gulf, from Wyndham, and to the south-west of Kununurra in Western Australia (Fig. 3). Cambridge Gulf populations are found behind supratidal flats near Kununurra and Wyndham populations near wetlands and seasonal creeks.

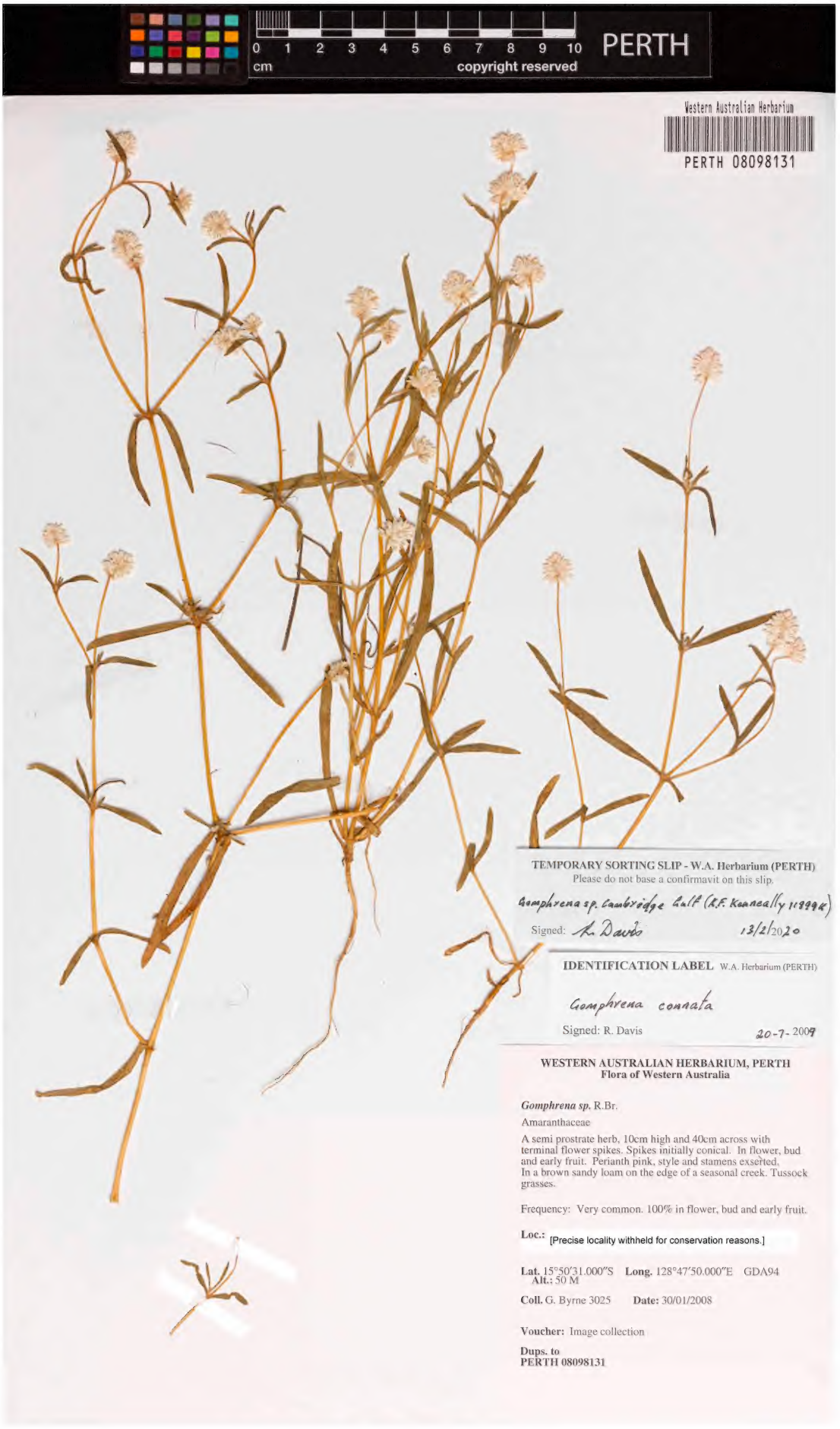
Conservation status. *Gomphrena longistyla* is listed as Priority 2 under Conservation Codes for Western Australian Flora and Fauna, under the name *G.* sp. Cambridge Gulf (Smith & Jones 2018).

Etymology. The epithet is from the Latin *longus* (long) and *stylus* (style) in reference to this species having a relatively long style protruding from the sepal apex.

Notes. First recognised as a possible new species in 2004 by J. Palmer as having similarities to *G. connata* J.Palmer, but differed in its stamens, staminal appendage and tube. *Gomphrena* sp. Cambridge Gulf was subsequently given a phrase-name by R. Davis in 2020.

Other specimens examined [precise localities withheld for conservation reasons]

WESTERN AUSTRALIA. Parry Lagoons Nature Reserve, 11 Nov. 1997, *Anonymous s.n.* (PERTH); Durack River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PERTH
Western Australian Herbarium
PERTH 08098131
TEMPORARY SORTING SLIP - W.A. Herbarium (PERTH)
Please do not base a confirmavit on this slip.
Gomphrena sp. Cambridge Gulf (K.F. Kenneally 11994)
Signed: R. Davis 13/2/2020
IDENTIFICATION LABEL W.A. Herbarium (PERTH)
Gomphrena connata
Signed: R. Davis 20-7-2009
WESTERN AUSTRALIAN HERBARIUM, PERTH
Flora of Western Australia
Gomphrena sp. R.Br.
Amaranthaceae
A semi prostrate herb, 10cm high and 40cm across with terminal flower spikes. Spikes initially conical. In flower, bud and early fruit. Perianth pink, style and stamens exserted. In a brown sandy loam on the edge of a seasonal creek. Tussock grasses.
Frequency: Very common. 100% in flower, bud and early fruit.
Loc.: [Precise locality withheld for conservation reasons.]
Lat. 15°50'31.000"S Long. 128°47'50.000"E GDA94
Alt.: 50 M
Coll. G. Byrne 3025 Date: 30/01/2008
Voucher: Image collection
Dups. to
PERTH 08098131

Fig 1. Holotype of *Gomphrena longistyla*, *G. Byrne 3025* (PERTH08098131).

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HOLOTYPE
Australian National Herbarium (CANB)
Gomphrena axillaris R.W.Davis & J.Palmer
DET. J. Palmer 19 July 2021
WESTERN AUSTRALIAN HERBARIUM, PERTH
Flora of Western Australia
Gomphrena sp.
Det.:
Amaranthaceae
15-20 cm high, many flower heads in clusters of 3-4, very light greenish-cream colour.
On sandy clumps on edge of tidal flats.
Abundance: only 2-3 plants seen.
Loc.: SSE of Cape Bertholet, Dampier Peninsula, W Kimberley WA
Lat. 17^ 16' " S Long. 122^ 10' " E
Coll.: B.J. Carter 600 Date: 08 08 1992
Dups. to Broome
PERTH Sheet No. 02472228

Fig 2. Holotype of *Gomephrena axillaris*, *B.J. Carter 600* (PERTH02472228).

Station, 5 June 2014, *R. Butcher & A.N. Start RB 1957* (PERTH); SE of New Wyndham Post Office, 25 Apr. 1977, *Hj. Eichler 22495* (CANB, PERTH); Adolphus Island, 10 Aug. 2008, *T. Handasyde TH 4083* (CANB, PERTH); Adolphus Island, 9 Feb. 2009, *T. Handasyde TH 6232* (CANB, PERTH); Adolphus Island, 9 Feb. 2009, *T. Handasyde TH 6255* (CANB, PERTH); Adolphus Island, 9 Feb. 2009, *T. Handasyde TH 6256* (CANB, PERTH); Nicholls Point, Adolphus Island, Cambridge Gulf, 15 June 2003, *K.F. Kenneally 11899 K* (CANB, PERTH); Near Grant Creek Bore, 70 km N of Kununurra and c. 31 km NNW of Point Springs, 8 Mar. 1978, *M. Lazarides 8432* (CANB, PERTH); SSE of Kununurra, 10 Mar. 1978, *K. Paijmans 2226* (CANB, PERTH); NNE of Wyndham, 14 Mar. 1978, *K. Paijmans 2229* (CANB, PERTH).

Gomphrena axillaris R.W.Davis & J.Palmer, *sp. nov.*

Holotypus: [precise locality withheld for conservation reasons] SSE of Cape Bertholet, Dampier Peninsula, W. Kimberley, Western Australia, 8 August 1992, *B.J. Carter 600* (PERTH02472228).

Gomphrena sp. Martins Well (*K.F. Kenneally 6116*). Western Australian Herbarium, *FloraBase* https://florabase.dbca.wa.gov.au/ [accessed: 14 February 2020].

Gomphrena sp. O (J.Palmer) in Kenneally, D.C.Edinger & T.Willing, *Broome & Beyond Pl. People Dampier Penins.* 57 (1996).

Gomphrena sp. Doongmabulla (*E.J.Thompson+ GAL137*) in Henderson, R.J.F. (ed.), *Names Distrib. Queensl. Pl. Algae Lichens* 14 (2002).

Annual or occasionally biennial herb, erect, 10–30 cm high, up to 20 cm wide, single or multi-stemmed at ground level. *Stems* terete, glabrous or with sparse to dense, tangled, white cottony hairs especially on younger stems and in leaf axils. *Leaves* cauline, sessile, linear to very narrowly ovate, 10–35 (–40) mm long, 0.9–2.3 (–3) mm wide; margins recurved to revolute, entire; upper and lower surface glabrous; apex acute, mucronate. *Inflorescences* axillary, sessile, solitary or in clusters of 2–3, ovoid to shortly cylindrical, pink or white, 5–16 (–20) mm long, 4–8 mm wide, elongating as mature flowers fall. *Bracts* ovate, persistent after flowers shed, 1.0–2.2 mm long, 1.0–2.0 mm wide, sessile to subsessile, entire, glabrous, apex acute, translucent or slightly opaque on the distal portion; mid-nerve faint. *Bracteoles* broadly ovate to ovate, falling with flowers, 2.0–3 (–3.5) mm long, 1.2–2.6 mm wide, equal or slightly longer or shorter than sepals, translucent or rarely opaque for a third of length, entire, glabrous, apex acute; mid-nerve faint. *Sepals* 5; *outer sepals* 3, oblong to narrowly ovate, pink or light greenish-cream or white, 2.0–3.4 mm long, 0.5–1 mm wide; margin entire; apex tapering to a short tip, obtuse to rounded, entire; mid-nerve terminating before sepal apex or rarely faintly terminating at apex; outer surface with dense white or pale brown, tangled, woolly hairs, covering three quarters to almost full length of the sepals; inner surface glabrous; *inner sepals* 2, oblong to narrowly ovate, smaller than outer sepals, 1.5–2.9 mm long, 0.2–0.7 mm wide, margin entire; apex gradually tapering, acute to obtuse, entire; outer surface with dense white or pale brown, tangled, woolly hairs, covering over three quarters to almost full length of the sepals; inner surface glabrous. *Stamens* 5, 0.8–1.7 mm long; *androecial tube* shorter than fruit, 0.4–0.8 mm long; *androecial tube appendages* absent; *filaments* pink, 0.2–0.6 mm long; apex apiculate; *anthers* 0.2–0.6 mm long. *Style* 0.1–0.5 mm long, pink; *stigma* 0.05–0.2 mm long. *Fruit* oblong, ovoid or ellipsoid, 1.2–1.7 mm long, 0.8–1.1 mm wide. *Seed* compressed, ovoid, brown, 0.7–1.2 mm long, 0.6–0.9 mm wide. **Fig. 2.**

Diagnostic characters. *Gomphrena axillaris* can be distinguished from all other Australian species of the genus in being an erect, annual herb, with mostly axillary, sessile, clustered, pink, ovoid to shortly cylindrical spikes (4–8 mm wide), the staminal appendages absent, a style 0.1–0.5 mm long and a stigma 0.05–0.2 mm long.

Phenology. From the specimens examined, flowering occurs in autumn and winter, from March to May and July to August; however, it is likely *G. axillaris* would respond to ephemeral rain events.

Distribution and habitat. *Gomphrena axillaris* is currently known from several localities (Fig. 3), in Western Australia (near Karratha, the Dampier Peninsula and Lake Disappointment), the Northern Territory (near the Western Australian border, 60 km south-east of Lake Mackay, in the Tanami Sanctuary and near Lake Caroline Station, west of the Queensland border), and central Queensland (Yarrowmere Station in the north, down to east of Barcaldine in the south). The collection labels suggest it prefers sub-saline habitats or margins of salt-lakes and hummock or tussock grasslands on sand.

Conservation status. *Gomphrena axillaris* is listed as Priority 1 under Conservation Codes for Western Australian Flora and Fauna, under the name *G.* sp. Martins Well (Smith & Jones 2018). In Western Australia it is known from five locations, in the Pilbara near Karratha and Lake Disappointment in the Little

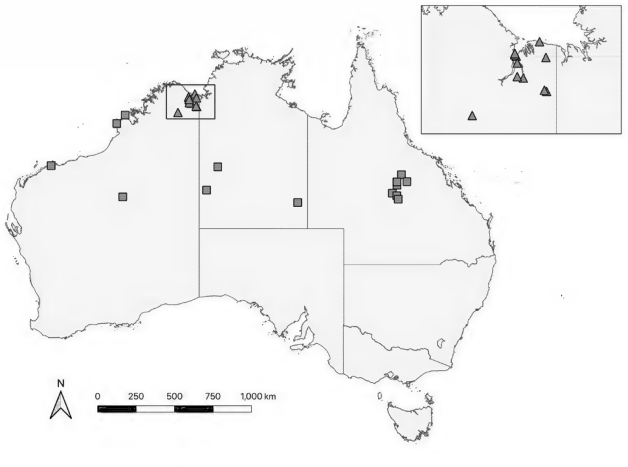

Fig 3. The distribution of *Gomphrena longistyla* (triangles) and *G. axillaris* (squares).

Sandy Desert and the Dampier Peninsula. With the recent discoveries of populations on the Dampier Peninsula the current priority listing for Western Australia will likely be re-evaluated. In the Northern Territory and Queensland, it is not conservation listed, however, it is noted as data deficient for the Northern Territory.

Etymology. The specific epithet derives from the Latin *axillaris* (of an axil), referring to the axillary inflorescences.

Related species. Using the Australian key to *Gomphrena*, *G. axillaris* keys out closest to *G. sordida*. Both species prefer saline habitats, but *G. axillaris* has an erect habit with clearly elongated inflorescences, of which are 2–4 commonly clustered together, whereas *G. sordida* has a prostrate or decumbent habit, commonly single inflorescences or occasionally 2 or 3 clustered and barely elongated. *G. sordida* is restricted to the Pilbara and Carnarvon bioregions, *G. axillaris* is distributed from the Pilbara across to the Northern Territory and central western Queensland. *Gomphrena axillaris* is also similar to *G. leptophylla*, but that species has a more prostrate habit, longer style (0.2–1.0 mm) and stigma (0.1–0.4 mm) and has androecial tube appendages.

Other specimens examined [precise localities withheld for conservation reasons]

WESTERN AUSTRALIA. Sherlock River, 1878, *Forrest s.n.* (MEL); SW of Martins Well, Dampierland, N of Broome, 22 Apr. 1977, *K.F. Kenneally 6116* (PERTH); Lake Disappointment, 23 Aug. 2004, *W.P. Muir WPM 713* (PERTH); Site DAM06-13, Dampier Salt Site between Dampier and Karratha, 2006, *R. Orifici s.n.* (CANB); S of Dampier, 13 July 2008, *R. Orifici BES 00491*(PERTH).

NORTHERN TERRITORY. NE Mt Morris, 15 Apr. 1997, *D.E. Albrecht 8172* (CANB); Near E edge of first major lake, South of Lake Caroline, North Simpson Desert, 10 July 2007, *D.E. Albrecht & A. Duguid 12347* (CANB); Tanami Sanctuary, 25 May 1976, *P. Latz 6482 p.p.* (CANB).

QUEENSLAND. Geera, E of Barcaldine, 6 Dec. 1935, *S.T. Blake 10385* (AD, BRI, NT); Corinda, c. 100 km N of Aramac (DEU site 531), 31 Mar. 2004, *R.J. Cumming 22473 & E.J. Thompson* (BRI); Thornhill east of Barcaldine, June 1995, *J. Elsol s.n.* (BRI); 93 km E of Muttaburra on stock route through Sumana Station, 4 Apr. 2011, *E.J. Thompson MUT475* (BRI); 104 km NE of Muttaburra on Corinda Station, SE of Corinda homestead, 31 Mar. 2005, *E.J. Thompson MUT196 & R.J. Cumming* (BRI); S of Doongmabulla homestead, 197 km N of Jericho, 18 Mar. 1993, *E.J. Thompson GAL137 & E.J. Henderson* (BRI); Yarrowmere Station, SW of Yarrowmere homestead, 2 May 2006, *E.J. Thompson BUC2206 & G.W. Wilson* (BRI).

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Swainsona 35: 65–66 (2021)
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SHORT COMMUNICATION

×*Phelodia*, a new nothogenus in Australian Orchidaceae

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Hybrids between the Australian orchid species *Glossodia major* R.Br. and *Caladenia deformis* R.Br. are known under the name ×*Glossadenia tutelata* (R.S.Rogers) Kellermann, and placed in the nothogenus ×*Glossadenia* Kavulak (Kellermann & Monro 2021). If however a narrower concept of *Caladenia* R.Br. is used, with the segregate genus *Pheladenia* D.L.Jones & M.A.Clem. recognised as distinct, the second parent species is to be treated as *Pheladenia deformis* (R.Br.) D.L.Jones & M.A.Clem. There are currently no validly published nothogeneric or nothospecific names available for the hybrid taxon using this parental circumscription.

The *International Code of Nomenclature for algae, fungi, and plants* (ICN; Turland *et al.* 2018) states that the nothogeneric name of a bigeneric hybrid is a condensed formula combining the names adopted for each parental taxon (ICN Art. H.6.2). If the name adopted for a parent genus changes, then the nothogeneric name has to follow (ICN Art. 8.1, H.6 Ex. 3).

While some publications still retain the traditional broader circumscription of *Caladenia*, the major Australian herbaria are now generally accepting *Pheladenia*. Hence, it is necessary to publish both a new nothogeneric name for hybrids between *Pheladenia* and *Glossodia* R.Br. and a new combination for the included nothospecies.

The complex history of the nothogenus (as ×*Glossadenia* Kavulak) was discussed in Kellermann & Monro (2021). Jeanes (Jeanes & Backhouse 2006) and Shaw (2014) have previously attempted to publish a nothogeneric name for hybrids between *Pheladenia* and *Glossodia*, both using the name "×*Glossadenia*". However, as these authors published later homonyms of ×*Glossadenia* Kavulak, their names cannot be used.

×*Phelodia* Kellermann, ***nothogen. nov.***

×*Glossadenia* Kavulak, *Austral. Nat. Orch. Hybr. Guide* 7 (1986). — Stated parentage: *Glossodia* R.Br. × *Caladenia* R.Br.

×*Calassodia* M.A.Clem. ex D.L.Jones, *Nat. Orchids Austral.* 621 (1988). — Stated parentage: *Caladenia* R.Br. × *Glossodia* R.Br.

×*Calassodia* M.A.Clem., *Austral. Orchid Res.* 1: 33 (1989), isonym. — Stated parentage: *Caladenia* R.Br. × *Glossodia* R.Br.

×*Glossadenia* Jeanes in Jeanes & G.N.Backhouse, *Wild Orchids Vic. Austral.* 124 (2006), *non* Kavulak (1986) [later homonym]. — Stated parentage: *Glossodia* R.Br. × *Pheladenia* D.L.Jones & M.A.Clem.

×*Glossadenia* J.M.H.Shaw, *Quart Suppl. Int. Reg. Orchid Hybr. (Sander's List)* 122(1305): 16 (2014), *non* Kavulak (1986) [later homonym]. — Stated parentage: *Glossodia* R.Br. × *Pheladenia* D.L.Jones & M.A.Clem.

Parentage statement. A bigeneric hybrid between *Pheladenia* D.L.Jones & M.A.Clem. and *Glossodia* R.Br.

Etymology. The name is a combination of parts of the names of the two genera that are parents of this hybrid taxon, i.e. *Phel*[*adenia*] and [*Gloss*]*odia*.

×*Phelodia tutelata* (R.S.Rogers) Kellermann, ***comb. nov.***

Caladenia ×*tutelata* R.S.Rogers, *Trans. Proc. & Rep. Roy. Soc. South Australia* 31: 211 (1907), *pro sp.* — ×*Calassodia tutelata* (R.S.Rogers) M.A.Clem., *Austral. Orchid Res.* 1: 33 (1989). — ×*Glossadenia tutelata* (R.S.Rogers) Kellermann in Kellermann & A.M.Monro, *Swainsona* 35: 39 (2021). — **Type citation:** "discoveries on August 24 of this year" [1907]. **Lectotype:** Blackwood, 24 Aug. 1907, *E. Ashby s.n.* (AD97522357), *fide* Kellermann & A.M.Monro,

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Swainsona 35: 39 (2021). **Isolectotype:** Blackwood, 24 Aug. 1907, [*E.*] *Ashby s.n.* (AD97522358A).

×*Glossadenia tutelata* Kavulak, *Austral. Nat. Orch. Hybr. Guide* 7 (1986), *nom. nud. & inval.*

×*Calassodia tutelata* D.L.Jones, *Nat. Orchids Austral.* 621 (1988), *nom. inval.*

Glossodia ×*tutelata* M.W.Harrison & M.J.G.Corrigan, *Checkl. Austral. Nat. Orch. Hybr. Ed. 5*, 24, 61 (1993), *nom. inval.*

×*Glossadenia tutelata* Jeanes in Jeanes & G.N.Backhouse, *Wild Orchids Vic. Austral.* 124 (2006), *nom. inval.*

Parentage statement. A hybrid between *Pheladenia deformis* (R.Br.) D.L.Jones & M.A.Clem. and *Glossodia major* R.Br.

Note. The history, typification and etymology of the name were discussed by Kellermann & Monro (2021). Detailed descriptions and illustrations of the nothospecies can be found in Entwisle (1994) (as ×*Calassodia tutelata*) and Jones (2021: 211) (as ×*Glossadenia tutelata*).

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Validation of Henry Imshaug's "*Ochrolechia alectoronica*" (lichenised Ascomycetes, Pertusariales), with notes on *O. weymouthii* Jatta and a key to the genus *Ochrolechia* in Tasmania

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Abstract: Two species of the lichen genus *Ochrolechia* from cool temperate latitudes of the Southern Hemisphere are described and illustrated: *O. alectoronica* Imshaug ex Kantvilas & Fryday *sp. nov.*, validated on a type from Campbell Island and also occurring in Tasmania and the Auckland Islands; and *O. weymouthii* Jatta, widespread in Tasmania and the southern mainland of Australia. Both taxa are characterised by an esorediate thallus containing alectoronic acid. The southern South American species *O. blandior* (Nyl.) Darb. is a synonym of *O. weymouthii*. A key to the seven species of *Ochrolechia* occurring in Tasmania is provided.

Keywords: alectoronic acid, lichens, Southern Hemisphere, Australia, New Zealand

Introduction

In a recent review of Tasmanian collections of the large, cosmopolitan crustose lichen genus *Ochrolechia*, the first author encountered a saxicolous taxon which, at first glance and on study of the available literature, appeared to be undescribed. However, further perusal of herbarium collections revealed that this same species had been previously collected by Henry Imshaug and Richard Harris from Campbell Island and the Auckland Islands in the Southern Ocean, and distributed to various herbaria under the unpublished name "*O. alectoronica* Imshaug". This species appeared to be most similar to a corticolous taxon, originally described by the Italian lichenologist Antonio Jatta (Jatta 1910) from a specimen collected from Tasmania by resident botanist William Anderson Weymouth, better known for his contributions to bryology, and named in his honour as *O. weymouthii* Jatta. Because the type specimen of this species had been generally unavailable for study, this name was not taken up by lichenologists, nor placed into synonymy with any other species. However, we are now able to provide the first detailed description of *O. weymouthii*, based on a comprehensive range of collections. We also validate Imshaug's "*O. alectoronica*". Both taxa are considered in the context of the genus in Tasmania and an identification key is provided for Tasmanian taxa.

Materials and methods

The study is based on collections housed in the Tasmanian Herbarium, Hobart (HO) and the herbarium of Michigan State University, Lansing (MSC), with reference to selected specimens, including types, from other herbaria as indicated in the text. Anatomical observations and measurements are based on thin, hand-cut sections of the thallus and apothecia, mounted in water, 10% KOH (K), Lugol's Iodine, ammoniacal erythrosin and/or Lactophenol Cotton Blue. Calcium oxalate was detected by eluting thin-sections of the thallus and apothecia with 25% H_2SO_4 under high power magnification. Ascospore measurements are presented in the format 5th percentile–*average*–95th percentile, with outlying values in brackets and *n* signifying the number of observations. Ascospores in *Ochrolechia* can sometimes span remarkable size ranges, depending on age, and it was not uncommon to find very old, deformed spores lacking contents, or extremely thick-walled, over-mature, discoloured ascospores. Consequently, measurements were restricted to seemingly mature, well-formed ascospores with a well-defined wall to c. 2 µm thick. Chemical analyses were undertaken by thin-layer chromatography (TLC) using standard methods (Orange *et al.* 2010). Alectoronic acid, the principal compound in the two species studied, is easily detected on TLC plates when they are painted with 10% H_2SO_4 but *not* heated, showing up as a vividly

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Key to *Ochrolechia* in Tasmania

1. Thallus granular crustose to subfruticose, composed of entangled, ± terete strands and spinules which subtend or protrude from ± globose granules, containing gyrophoric acid (thallus C+ red); usually overgrowing terricolous or saxicolous bryophytes . . . . . ***O. frigida***

1: Thallus crustose, lacking strands and spinules, with or without gyrophoric acid (C+ red or C–); usually corticolous or saxicolous

2. Thallus sorediate, containing gyrophoric acid (medulla C+ red)

3. Thallus uneven, verruculose to bullate; soralia usually becoming confluent; ± exclusively alpine, scrambling over bryophytes on rocks, on the ground, or on the bases of trees . . . . . ***O. androgyna s.l.***

3: Thallus mostly smooth and even, with the soralia mostly discrete; on bark and wood from lowland to highland elevations . . . . . ***O. gyrophorica***

2: Thallus not sorediate, containing gyrophoric or alectoronic acid (medulla C+ red or C–)

4. Apothecia immersed in subglobose, thalline warts that open by 1–5 terminal pores; disc obscured; confined to highland elevations . . . . . ***O. xanthostoma***

4: Apothecia discoid and the disc exposed from an early stage; occurring across all elevations

5. Thallus saxicolous

6. Medulla of thallus and apothecial margin C+ red (containing gyrophoric acid); confined almost exclusively to coastal rocks . . . . . ***O. apiculata***

6: Medulla of thallus and apothecial margin C–, KC+ orange-pink (containing alectoronic acid); occurring in the hinterland in eucalypt woodland and heathland . . . . . ***O. alectoronica***

5: Thallus corticolous or lignicolous

7. Medulla of thallus and apothecial margin C+ red (containing gyrophoric acid as the major compound); thallus verruculose to coarsely granular; apothecia with a ± coronate margin and usually with the proper exciple visible; confined to lowland and coastal areas . . . . . ***O. africana***

7: Medulla of thallus and apothecial margin C–, KC+ orange-pink (containing alectoronic acid); thallus and apothecial margin generally smooth and the proper exciple obscured; ranging from lowland to highland elevations . . . . . ***O. weymouthii***

fluorescent, purple-blue spot. This reaction is not seen after the plate is heated.

Henry Imshaug's lichens

Henry A. Imshaug (1925–2010) is regarded as one of North America's most outstanding lichenologists (Brodo 2011). He spent most of his working life as the curator of the cryptogamic herbarium at the Michigan State University herbarium (MSC), where he assembled a major collection that, at the time of his retirement in 1990, numbered over 145,000 fully accessioned specimens, with an additional 200,000 unmounted specimens in separate research collections. The vast majority of these collections were lichens. Although his published output was meagre, his legacy is instead founded on this superb collection and the graduate students he trained in lichenology. These included the lichenologists Clifford Wetmore, Irwin Brodo and Richard Harris, and the bryologist John Engel, all of whom made enormous, globally significant scientific contributions in their specialist topics.

Imshaug's exploration of the southern subpolar region began on the Juan Fernandez Islands in 1965, included the Falkland Islands, southern Chile and Argentina (including Isla de los Estados and Tierra del Fuego), Campbell Island and Îles Kerguelen, and ended on the Auckland Islands in 1972–73. In this remarkable burst of sustained collecting, he (along with his students and co-workers, Richard Harris, Karl Ohlsson and the Tasmanian Geoff Bratt) made c. 18,000 collections of lichens (Fryday & Prather 2001). These collections are often the major, if not the only, resource of lichens from these difficult to reach areas, and it is to Imshaug's credit that his collections are superb, usually comprising a large piece of rock or bark with a well-developed specimen of the species in question. Wherever possible he also made multiple collections, many of which have been distributed to other herbaria as duplicates.

For those who have had the privilege of studying Imshaug's collections, the impression is inevitably one of amazement at how accurate many of his determinations are, often from crustose lichen groups that were poorly known at the time globally, let alone in the austral zone. He displayed a remarkable ability to uncover the correct names for his specimens, or to at least ascribe them to the names of best fit for the era. He also clearly had a unique eye for detecting novelties, giving herbarium names to over 100 taxa that have since been either validated or described as new by others (e.g., Messuti & Archer 1999; Kantvilas 2009; Fryday 2019). Validation here of his *Ochrolechia alectoronica* continues this trend.

Taxonomy

Ochrolechia alectoronica Imshaug ex Kantvilas & Fryday, ***sp. nov.***

Species saxicola, Ochrolechiae apiculatae *Verseghy similis, sed acidum alectoronicum continenti differt.*

Holotypus: New Zealand, Campbell Island: on marine and seashore rocks at base of Mt Honey, across from Beeman Station, [52.558°S 169.155'E], 31 Dec. 1969, *R.C. Harris 4974* (HO317745). **Isotypi:** MSC 0000880, OSC142473.

Mycobank number: MB841108

Thallus creamish white, bullate-papillate, with the papillae densely congested and overlapping, to c. 1 mm tall and 1.5 mm wide, or with the papillae highly reduced to almost absent, granular and rather dispersed, to 0.3 mm wide, esorediate; prothallus not developed; calcium oxalate absent or present only in very minor amounts in the medulla or apothecial pruina. Apothecia 1–2.5 mm diam., scattered; disc concave to plane, pale pink to orange-brown, thinly whitish grey pruinose; thalline margin 0.2–0.8 mm thick, inrolled, smooth to crenulate, sometimes a little radially cracked, in section hyaline, 250–650 µm thick at the sides; proper exciple highly reduced and not visible externally, in section 40–60 µm thick. Hypothecium 40–80 µm thick, hyaline. Hymenium 270–300 µm thick, sometimes inspersed with scattered oil droplets, overlain by a greyish brown, crystalline epithecial layer to 40 µm thick, sometimes transiently pale yellowish and partly dissolving in K. Asci initially 8-spored, usually with as many as 4 spores aborted at maturity, 240–300 × 40–65 µm. Ascospores (50–) 56–*67.6*–82 (–84) × (26–) 30–*38.6*–50 µm (*n* = 80), broadly ellipsoid to ovate; wall 1–2 µm thick. **Fig. 1.**

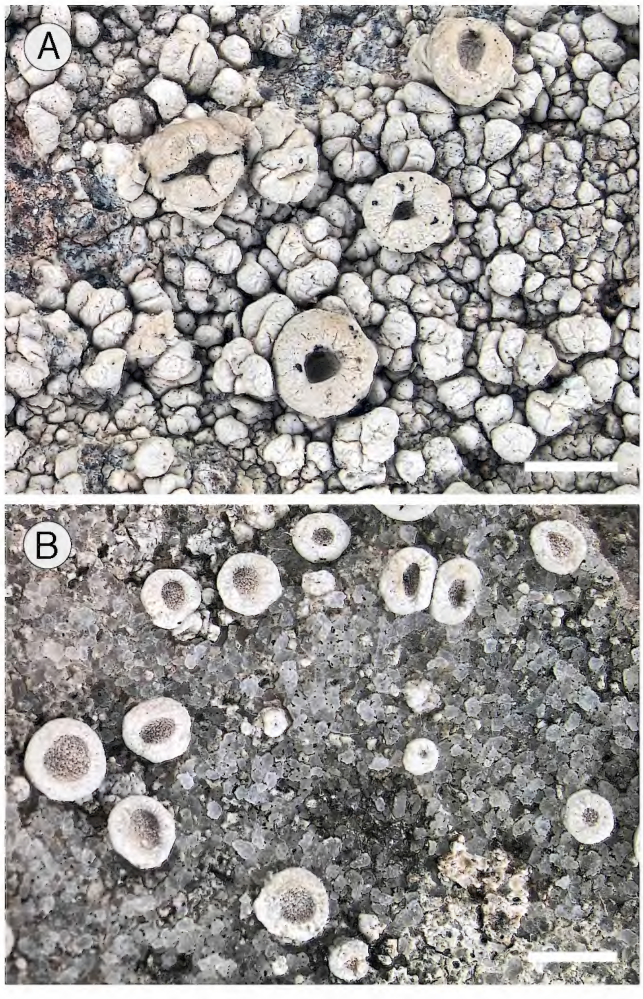

Fig. 1. ***Ochrolechia alectoronica*** habit. **A** Holotype, Campbell Island, with a highly papillate-bullate thallus and the apothecial disc partially obscured by the inrolled margin. **B** *Kantvilas 323/14* (Tasmania), with the thallus highly reduced and the apothecial disc exposed. Scales = 2 mm.

Chemistry: Alectoronic acid in the thallus and apothecial margin (medulla K–, KC+ orange-pink, C–, P–, UV+ white); gyrophoric and lecanoric acids in the apothecial disc (K–, KC+ red, C+ red, P–, UV± bluish white).

Etymology. Imshaug's specific epithet refers to the chemical composition of the species.

Remarks. *Ochrolechia* is primarily a corticolous or lignicolous genus, or occurs on organic substrata such as bryophytes and humus, and there are relatively few species that grow directly on rock; for example, see Verseghy (1962), Galloway (2007) and Kukwa (2011). In the Australasian region, the most common and widespread saxicolous taxon is *O. apiculata* Verseghy (McCarthy *et al.* 2017), which differs from *O. alectoronica* in its chemistry (gyrophoric acid, medulla C+ red) and somewhat smaller ascospores [(34–) 41–*56.5*–72 (–80) × (24–) 26–*33.5*–44 (–48) µm; this study]. In addition, calcium oxalate, which is very abundant in the thallus of *O. apiculata*, is absent or found in only very minor, scattered quantities in *O. alectoronica*. A further saxicolous taxon in Australia is the Kangaroo Island endemic, *O. insularis* Kantvilas & Elix (see Lumbsch *et al.* 2011), but this too differs from *O. alectoronica* by containing gyrophoric acid in the thallus. Galloway (2007) records two saxicolous Northern Hemisphere species from New Zealand, but almost certainly in error: *O. tartarea* (L.) A.Massal., which he incorrectly considered to be an earlier name for *O. apiculata* (McCarthy *et al.* 2017), and *O. parella* (L.) A.Massal., which occupies the same ecological niche as *O. apiculata*, but differs by containing variolaric acid in the cortex of the thallus and apothecial margin, and reacts C+ yellow (Kukwa 2011). Ertz *et al.* (2016) showed that specimens from South America identified as this species were only distantly related to *O. parella* and its occurrence in the Southern Hemisphere is very doubtful.

The type collection of *O. alectoronica* is from littoral rocks, but the range of collections from Campbell Island indicates that it also occurs on rock outcrops in *Dracophyllum*-dominated scrub and peat bogs, and in tussock grassland on mountain summits. In Tasmania, *O. alectoronica* is found only in the hinterland, colonising large outcrops and bluffs of sandstone and quartzite in heathland and open eucalypt forest, whereas *O. apiculata* is confined strictly to the coast.

The thallus of *O. alectoronica* can be quite variable. The type collection has a very markedly congested, bullate-papillate thallus with the apothecial margin very thick and inrolled, almost obscuring the disc (Fig. 1A). Other collections, however, range from such a morphology through to a more reduced, ± granular thallus, to ones where the thallus is almost absent and consists of widely scattered small granules, and the apothecial disc is widely exposed (Fig. 1B). One collection (*GK 150/86*) displays this entire range of morphology. All nevertheless display the salient feature of containing alectoronic acid.

The most similar species to *O. alectoronica*, at least with respect to chemical composition and ascospore size, is *O. weymouthii*, which is exclusively corticolous or lignicolous. This species has a generally thin, smooth thallus that ± follows the texture of the substratum, at most becoming rimose or verruculose but never papillate or granular.

Selected additional specimens examined

AUSTRALIA, TASMANIA. Grass Tree Hill, 42°47'S 147°22'E, 400 m, 14 Aug. 1981, *G. Kantvilas 704/81 & P. James* (BM, HO); Sisters Hills, 6 June 1986, *G. Kantvilas 150/86* (HO); Mt Wellington, Crocodile Rock, 42°53'S 147°15'E, 725 m, 17 Aug. 2014, *G. Kantvilas 323/14* (HO); *ibid.*, 1 Jan. 2018, *G. Kantvilas 3/18* (HO); Hungry Flats Road, 42°31'S 147°28'E, 420 m, 17 Aug. 2021, *G. Kantvilas 330/21* (HO).

NEW ZEALAND, CAMPBELL ISLAND. Summit ridge of St Col Peak, 52.54°S 169.13°E, 22 Dec. 1969, *H.A. Imshaug 45941*, *46000* (MSC); N side of Perseverance Harbour at base Mt Lyall, 52.54°S 169.17°E, 22 Dec. 1969, *R.C. Harris 4306* (MSC); Filhol-Honey saddle, 52.58°S 169.15°E, 23 Dec. 1969, *H.A. Imshaug 46011* (MSC); summit ridge of Beeman Hill, 52.55°S 169.15°E, 24 Dec. 1969, *R.C. Harris 4536*, *4555* (MSC); E side of Tucker Cove, 52.55°S 169.15°E, 24 Dec. 1969, *R.C. Harris 4523* (MSC); N side of Beeman Hill, 52.54°S 169.15°E, 26 Dec. 1969, *R.C. Harris 4608*, *4612*, *4618* (MSC); summit of Menhir Peak, 52.55°S 169.04°E, 28 Dec. 1969, *H.A. Imshaug 46280* (MSC); between Mt Azimuth and Courrejolles Peninsula, 52.49°S 169.16°E, 30 Dec. 1969, *H.A. Imshaug 46340* (MSC); Mt Lyall pyramid, 52.54°S 169.17°E, 2 Jan. 1970, *H.A. Imshaug 46443* (MSC); summit of Filhol Peak, 52.58°S 169.13°E, 4 Jan. 1970, *R.C. Harris 5096* (MSC); stream NE of Mt Sorenson, 52.50°S 169.18°E, 6 Jan. 1970, *R.C. Harris 5102*, *5108* (MSC); E of Mt Sorenson, 52.50°S 169.18°E, 7 Jan. 1970, *R.C. Harris 5146* (MSC); W side of Monument Harbour, 52.54°S 169.17°E, 8 Jan. 1970, *H.A. Imshaug 46695* (MSC); E side of Tucker Cove, 52.55°S 169.15°E, 9 Jan. 1970, *H.A. Imshaug 46747* (MSC); W shore of Garden Cove, 52.56°S 169.13°E, 11 Jan. 1970, *R.C. Harris 5236* (MSC); summit of Moubray Hill, 52.55°S 169.23°E, 12 Jan. 1970, *H.A. Imshaug 46933* (MSC); Erebus Point and half-mile N, 52.54°S 169.17°E, 12 Jan. 1970, *R.C. Harris 5268*, *5272* (MSC); summit of Beeman Hill, 52.55°S 169.15°E, 14 Jan. 1970, *H.A. Imshaug 47040* (MSC); above Venus Cove on lower part of W slope of Mt Honey, 52.57°S 169.15°E, 15 Jan. 1970, *H.A. Imshaug 47097* (MSC); W of Camp Cove, 52.56°S 169.13°E, 15 Jan. 1970, *R.C. Harris 5412* (MSC); S side of Perseverance Harbour, 1 mile W of South Point, 52.54°S 169.17°E, 16 Jan. 1970, *R.C. Harris 5447* (MSC); N side of W end of Lyall ridge, 52.53°S 169.16°E, 18 Jan. 1970, *R.C. Harris 5557*, *5562* (MSC); near Bull Rock, 52.54°S 169.17°E, 19 Jan. 1970, *H.A. Imshaug 47274*, *47283* (MSC).

NEW ZEALAND, THE AUCKLAND ISLANDS. Rose Island, bay on N side of Lucas Head, E shore of island, 50.52°S 166.25°E, 14 Dec. 1972, *H.A. Imshaug 56398* (MSC); Auckland Island, S side of inner part of Musgrave Inlet, 19 Dec. 1972, *H.A. Imshaug 56594*, *56600* (MSC); Auckland Island, NW end of North Arm, Carnley Harbour, N of Figure of Eight Island, 28 Dec. 1972, *H.A. Imshaug 56999* (MSC); Adams Island, W end of Bollons Bay, 50.88°S 166.08°E, 31 Dec. 1972, *H.A. Imshaug 57141* (MSC).

According to the Consortium of North American Lichen Herbaria website (CNALH 2021), additional duplicates are also housed in the following herbaria: CANB, DUKE, F, MIN & US.

Ochrolechia weymouthii Jatta

Boll. Soc. Bot. Ital. 1910: 255 (1911) [1910]. — **Holotype:** Tasmania, ad Sassafrages in monte Wellington, alt 600 p [180 m elev.], *W.A. Weymouth s.n.* (NAP!).

Ochrolechia blandior (Nyl.) Darb., *Lich. Swed. Antarct. Exped.* 50 (1912). — *Lecanora parella* * *blandior* Nyl., *Lich. Fueg. Patag.* 8 (1888). — **Holotype:** Argentina, Tierra del Fuego, Ushuwaia super corticem *Fagi antarcticae* (H-Nyl.!).

Thallus greyish white, typically smooth and following the texture of the substratum, or becoming rimose or verruculose, continuous to rather patchy, 50–200 (–250) µm thick, esorediate; prothallus not developed; calcium oxalate absent or only occasionally detected. Apothecia 0.8–2.6 mm diam., scattered or crowded together; disc concave to plane, pale pink to orange, thinly whitish grey pruinose or occasionally epruinose; thalline margin 0.15–0.5 mm thick, inrolled, smooth and entire, or becoming verruculose and crenulate, especially along the inner edge, occasionally radially cracked and rather scabrid, in section hyaline, 150–280 µm thick at the sides; proper exciple highly reduced and not visible externally, in section 20–40 µm thick. Hypothecium 35–50 µm thick, hyaline to pale yellowish, intensifying yellow in K. Hymenium 230–350 µm thick, moderately to densely inspersed with oil droplets, overlain by a diffuse greyish brown, crystalline epithecial layer to 50–60 µm thick, transiently pale yellowish and partly dissolving in K. Asci up to 8-spored but occasionally with 2–6 spores aborted at maturity, 215–290 × 58–70 µm. Ascospores (50–) 54–*69.1*–82 (–86) × (26–) 28–*36.2*–44 (–45) µm (n = 80), broadly ellipsoid to ovate; wall 0.5–2 µm thick. **Fig. 2.**

Chemistry: alectoronic acid in the thallus and apothecial margin, sometimes only detectable by TLC (medulla K–, KC+ orange-pink, C–, P–, UV+ white); gyrophoric acid in the apothecial disc (K–, KC+ red, C+ red, P–, UV+ bluish white).

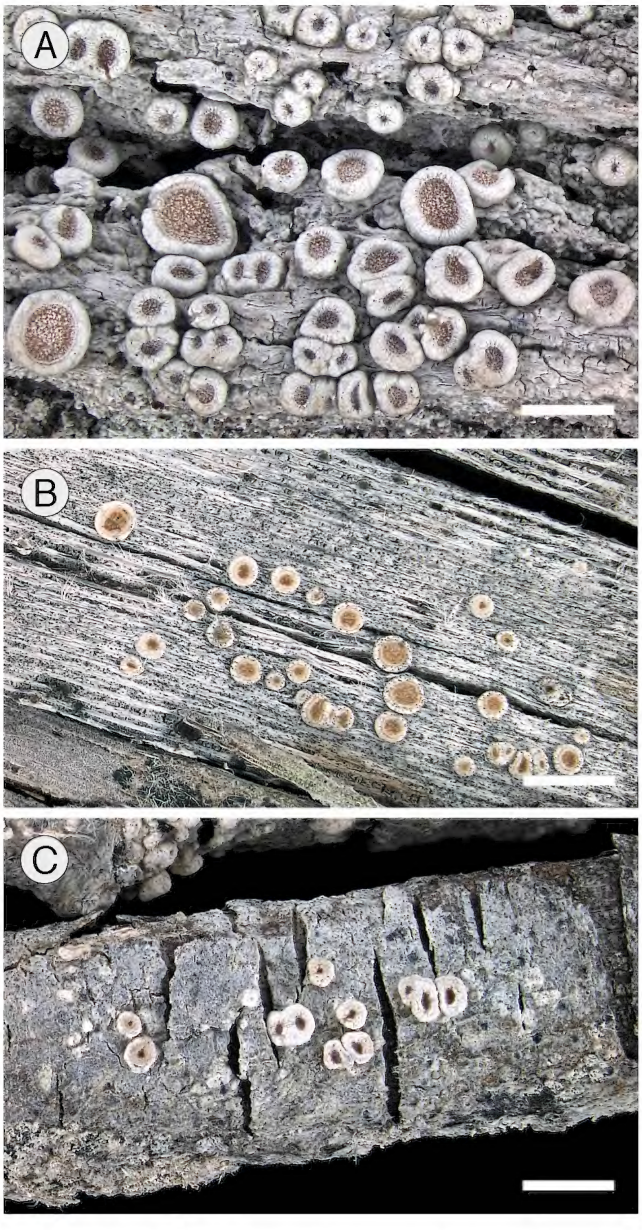

Fig. 2. ***Ochrolechia weymouthii*** habit. **A** *Kantvilas 204/21* (Tasmania); a typical, prominent thallus growing on a rotting log, with large apothecia. **B** *Kantvilas 69/21* (Tasmania); a thin thallus with small apothecia, growing on the dead leaves of *Richea pandanifolia*. **C** *James s.n.* (Tasmania); a very thin, patchy thallus with immature apothecia, growing on canopy twigs. Scales = 2 mm.

Remarks. *Ochrolechia weymouthii* is a very distinctive lichen, characterised by a corticolous or lignicolous habitat, a smooth, esorediate thallus containing alectoronic acid, apothecia with an entire thalline margin that entirely obscures the proper exciple, and a C+ red disc. It was first recorded for Australia (Victoria) by Elix (2009) and from Tasmania by de Salas *et al.* (2014) under its synonym, *O. blandior*, which is based on a type from southern South America.

The type specimen of *Ochrolechia weymouthii* is a tiny specimen, insufficient for chemical analysis or sectioning, but nevertheless enough to reveal its salient features. The provenance of the specimen and its habitat have been well-explored lichenologically, and only one species of *Ochrolechia* with the same characters as the type is known to occur there and has been collected multiple times. The above description is based chiefly on these and other Tasmanian specimens.

In older literature and in herbarium collections, this taxon has been referred to as *O. pallescens* (L.) A.Massal. and, in fact, Messuti & Lumbsch (2000) considered *O. blandior* as a synonym of that species. We do not accept this view but concur with Brodo (1991), Elix (2009) and Kukwa (2011), who all considered that *O. pallescens* was distinct and characterised by the presence of variolaric acid. The two taxa were also maintained as distinct by Verseghy (1962), distinguished by the smooth thallus (in *O. blandior*) versus granular-verruculose (in *O. pallescens*), and a putative, but unconfirmed (by us) ascospore size difference. *Ochrolechia pallescens* is widespread in the Northern Hemisphere and has been recorded from Isla de los Estados, Argentina (Brodo 1991). Although recorded for all Australian states and the A.C.T. by McCarthy (2020), no authentic specimens have been seen during the present study and its occurrence there, as well as in New Zealand (Galloway 2007) is considered doubtful.

Ochrolechia weymouthii is widespread and common in Tasmania where it occurs on bark and wood, particularly in forests at higher elevations. It is a highly variable species. On rotting logs, it forms conspicuous, widespreading colonies, with a thick, almost verruculose thallus and abundant, large, crowded apothecia with an exposed disc (Fig. 2A). In high alpine habitats, it may be found on the dead retained leaves of the arborescent heath, *Richea pandanifolia*. Here the thallus is extremely thin, the apothecia are small (Fig. 2B), and the species occurs in rather small patches, often amongst other lichens, including the superficially similar *Lecanora caesiorubella* Ach. On twigs, the thallus of O. weymouthii is very thin and patchy with relatively small, scattered apothecia with an inrolled margin (Fig. 2C). Every intermediate form can also be seen. The degree of inspersion of the hymenium appears to be environmentally influenced, and is most extreme in specimens from alpine areas.

Although *O. weymouthii* frequently occurs in the same forest sites as *O. gyrophorica* (A.W.Archer) A.W.Archer & Lumbsch, the two species are unlikely to be confused. The latter differs by having a sorediate thallus and contains gyrophoric acid, with the medulla of the thallus and apothecial margin, and the soredia reacting C+ red (see Archer 1992, as *Pertusaria gyrophorica*); it also has a different ecology. In such forests, *O. weymouthii* is most common on horizontal logs and is only rarely seen on standing trunks, whereas *O. gyrophorica* is restricted to the basal stockings of rotting bark on standing, ± vertical trees. Indeed, *O. weymouthii* is most similar to the saxicolous *O. alectoronica*, which differs chiefly by its substratum and granular to papillate-bullate thallus (see above). Future work using DNA sequence data may well show that these two taxa are conspecific, as

substratum preference is not a taxonomic character, even if it serves as a useful field spotting character. However, for the present, we consider the difference in thallus morphology sufficient to retain these taxa as distinct.

Selected specimens examined

AUSTRALIA, TASMANIA. Lake Esperance, 43°14'S 146°46'E, 980 m, 29 Mar. 1963, *P. James s.n.* (BM, HO); Milles Track, Mt Wellington, 42°55'S 147°14'E, 800 m, 16 May 1964, *G.C. Bratt & J.A. Cashin 1282* (HO); Lake Dobson, 42°41'S 146°35'E, 1030 m, 13 Aug. 1981, *G. Kantvilas 648/81 & P. James* (BM, HO); Quamby Bluff, 41°39'S 146°42'E, 1000 m, 10 Aug. 1985, *G. Kantvilas 199/85* (HO); Standard Hill, 30 km WSW of Deloraine, 41°33'S 146°18'E, 440 m, 28 Nov. 1988, *J.A. Curnow 2211* (B, CANB, HO, UPS); Bermuda Road, 43°04'S 146°57'E, 440 m, 25 Oct. 1990, *G. Kantvilas 587/90 & J. Jarman* (HO, K); southern slopes of Gunners Quoin, 42°46'S 147°20'E, 350 m, 28 Apr. 1992, *G. Kantvilas 197/92 & J.A. Elix* (HO); South Sister, near summit, 41°32'S 148°10'E, 800 m, 10 Nov. 2004, *G. Kantvilas 332/04* (HO); lake SE of Rim Lake, 42°01'S 146°11'E, 1140 m, 17 Jan. 2012, *K. Felton s.n.* (HO); Lost World, Mount Wellington, 42°53'S 147°14'E, 980 m, 30 May 2020, *G. Kantvilas 83/20* (HO); Twisted Tarn, 42°39'S 146°34'E, 1120 m, 8 Mar. 2021, *G. Kantvilas 69/21* (HO); Flat Rock Reserve, Western Lookout, 42°36'S 147°17'E, 500 m, 27 June 2021, *G. Kantvilas 204/21* (H, HO, MSC, UPS).

AUSTRALIA, VICTORIA. Cumberland River, 38°34'S 143°54'E, 13 Aug. 1972, *G.C. Bratt 72/714 & R.C. Weeks* (HO); Cement Creek, 37°42'S 145°44'E, 23 Oct. 1993, *G. Kantvilas 106/93, P.M. McCarthy & S. Louwhoff s.n.* (HO); Mt Donna Buang, 37°42'S 145°41'E, 16 June 1994, *S. Louwhoff 302* (HO); The Beeches, 37°20'S 145°50'E, Nov. 1996, *S. Louwhoff s.n.* (HO).

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A taxonomic revision of the semi-cryptic narrow-leaved mallees (*Eucalyptus* series *Porantherae*, Myrtaceae) from southern Australia

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Abstract: The semi-cryptic 'narrow-leaved mallees' (*Eucalyptus* series *Porantherae*, Myrtaceae) from southern Australia are taxonomically revised. A total of 29 terminal taxa (23 species, 5 autonymous subspecies and 6 non-autonymous subspecies) are recognised in the series. New taxa named are *E. austrina* L.A.S.Johnson & K.D.Hill ex D.Nicolle & M.E.French, *E. connexa* D.Nicolle & M.E.French, *E. dissimulata* Brooker subsp. *plauta* L.A.S.Johnson & K.D.Hill ex D.Nicolle & M.E.French, *E. ecdysiastes* K.D.Hill ex D.Nicolle & M.E.French, *E. efflorescens* L.A.S.Johnson & K.D.Hill ex D.Nicolle & M.E.French, *E. foecunda* Schauer subsp. *aeolica* D.Nicolle & M.E.French, *E. formanii* C.A.Gardner subsp. *circulata* D.Nicolle & M.E.French, *E. lunata* D.Nicolle & M.E.French, *E. omissa* D.Nicolle & M.E.French, *E. plumula* D.Nicolle & M.E.French, *E. rigidula* Maiden subsp. *clancularia* D.Nicolle & M.E.French, *E. rigidula* subsp. *interior* D.Nicolle & M.E.French, *E. sinuensis* K.D.Hill & L.A.S.Johnson ex D.Nicolle & M.E.French and *E. uncinata* Turcz. subsp. *crassifolia* D.Nicolle & M.E.French. For all taxa in the series, updated descriptions and distributions are provided (including distribution maps), as well as an identification key to the series.

Keywords: *Eucalyptus*, series *Porantherae*, Myrtaceae, taxonomy, identification key, new species, southern Australia

Introduction

Eucalyptus L'Hér. ser. *Porantherae* Benth. was named by Bentham (1867) in his *Flora Australiensis*. Bentham included 12 species in the series, only one of which, *E. uncinata* Turcz., is still included in the series as it is now recognised. The other 11 species included by Bentham consisted of nine box and one ironbark species that are now included in a different section (*E.* sect. *Adnataria* L.D.Pryor & L.A.S.Johnson ex Brooker), and a single mallee ash species (*E. stricta* Sieb. ex Spreng.) which is in a different subgenus (*E.* subg. *Eucalyptus*). Bentham's diagnosis for the series was based on "anthers small and globular, or broader than long, the cells distinct, opening in small circular pores". These characters apply to most of the species named but not *E. stricta*, which has reniform anthers opening by incurved or oblique, coalescing slits.

Blakely (1934) erected *Eucalyptus* sect. *Porantheroideae* Blakely which included the same 11 box and ironbark species included in Bentham's *E.* ser. *Porantherae*. Within this section Blakely erected *E.* ser. *Fruticosae* Blakely, nearest to the boxes and ironbarks, but distinct from them. He included *E. uncinata* in this series and assigned *E. stricta* to the distantly related *E.* ser. *Renantherae* Benth. (*E.* subg. *Eucalyptus*). Blakely's diagnosis for *E.* ser. *Fruticosae* is not very informative and does not mention the critically diagnostic anthers. Nevertheless, the four species named, *E. rigidula* Maiden, *E. leptophylla* F.Muell. ex Miq., *E. albida* Maiden & Blakely and *E. uncinata* make up a recognisably related group that are all included in *E.* ser. *Porantherae* as defined here. At the same time, he erected two varieties of *E. leptophylla*, viz. var. *leptorrhyncha* Blakely from near Fremantle in W.A. and var. *densa* Blakely from Nymagee in N.S.W. Blakely (1936) later published *E. leptophylla* var. *floribunda* Blakely from north-west of Knutsford in W.A. These three varieties were treated as synonyms of *E. leptophylla* by Johnson (1962) who also synonymised *E. leptophylla* with *E. foecunda* Schauer. Despite Blakely's placement of *E.* ser. *Fruticosae* near the remainder of *E.* sect. *Porantheroideae*, the groups are distinct and relatively unrelated, in that the species of *E.* ser. *Fruticosae* have bisected cotyledons and those of *E.* sect. *Porantheroideae* have bilobed cotyledons.

Following Johnson (1962), Pryor & Johnson (1971) accepted that *Eucalyptus leptophylla* was a synonym of *E. foecunda*, this latter species by implication occurring in the four mainland southern States. They erected the informal *E.* ser. 'Foecundae' which comprised five

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then-recognised species. Chippendale (1988) accepted Pryor & Johnson's (1971) classification of the relevant species and cited seven species for the series. He restored *E.* ser. *Porantherae* and nominated *E. uncinata* as the lectotype, implicitly following Bentham (1867). Brooker (2000) treated *E.* ser. *Porantherae*, and following fieldwork and growing seedlings recognised that *E. leptophylla* and *E. foecunda* were morphologically and geographically distinct species, although both are correctly assigned to *E.* ser. *Porantherae*. Brooker included 15 species in the series, which he divided into two subseries based on juvenile leaf characters.

A total of ten new species have been named in the series over the last 40 years. Ian Brooker took a particular interest in the series and was involved in the description of nine of these. Brooker (1979) described two new species in the series (*E. discreta* Brooker and *E. fruticosa* Brooker), and Brooker (1988) described a further six new species in the series (*E. dissimulata* Brooker, *E. hypochlamydea* Brooker, *E. kumarlensis* Brooker, *E. latens* Brooker, *E. perangusta* Brooker, and *E. salicola* Brooker). *Eucalyptus hypochlamydea* was later determined to be synonymous with *E. horistes* L.A.S. Johnson & K.D.Hill (Nicolle *et al.* 2005), which Johnson & Hill (1988) published only six months earlier than Brooker (1988). Brooker & Hopper (1993), in a paper describing a miscellany of 42 new species and subspecies from various taxonomic groups, named one species from *E.* ser. *Porantherae* (*E. olivina* Brooker & Hopper).

Throughout the last few decades, numerous other potentially unnamed taxa have been recognised in the series, especially by Lawrie Johnson and Ken Hill from the National Herbarium of N.S.W. They applied manuscript names to a number of *Eucalyptus* ser. *Porantherae* specimens at NSW. None of these manuscript names were published, and it has been difficult to ascertain their concept of many of their manuscript names due to the paucity of specimens bearing some of the manuscript names, the lack of any published and unpublished notes relating to the manuscript names, and because both Johnson and Hill are now deceased. Wherever possible, we have utilised their manuscript names in the valid publication of new taxa. Some of the same unnamed taxa, as well as other potential unnamed taxa, have also been identified by others, using other manuscript and/or phrase names (e.g. Brooker & Kleinig 1990; Slee *et al.* 2006; Nicolle *et al.* 2012; Nicolle 2013).

We here recognise 23 species and 11 subspecies (5 being autonymous subspecies) within *Eucalyptus* ser. *Porantherae*. We use the common name 'narrow-leaved mallees' for the series, as a number of its species are known by that name (e.g. *E. plumula* D.Nicolle & M.E.French, *E. latens*, *E. omissa* D.Nicolle & M.E.French and *E. leptophylla*) and many others otherwise have relatively narrow adult leaves (e.g. *E. formanii* C.A.Gardner, *E. perangusta*, *E. olivina*, *E. lunata* D.Nicolle & M.E.French, etc.). The two most recent taxonomic classifications of all the eucalypts, Brooker (2000: 108) and Nicolle (2019: 25), place *E.* ser. *Porantherae* in *E.* subg. *Symphyomyrtus* (Schauer) Brooker sect. *Bisectae* Maiden ex Brooker, between *E.* ser. *Caesiae* Brooker & Hopper and *E.* ser. *Heterostemones* Benth.

Brooker (2000) distinguishes *Eucalyptus* ser. *Porantherae* from closely-related taxa by the following combination of characters: 'Stamens club-shaped, all fertile, inflexed; anthers adnate; ovules in 4 vertical rows'. More broadly, the series is defined by its bisected cotyledons,

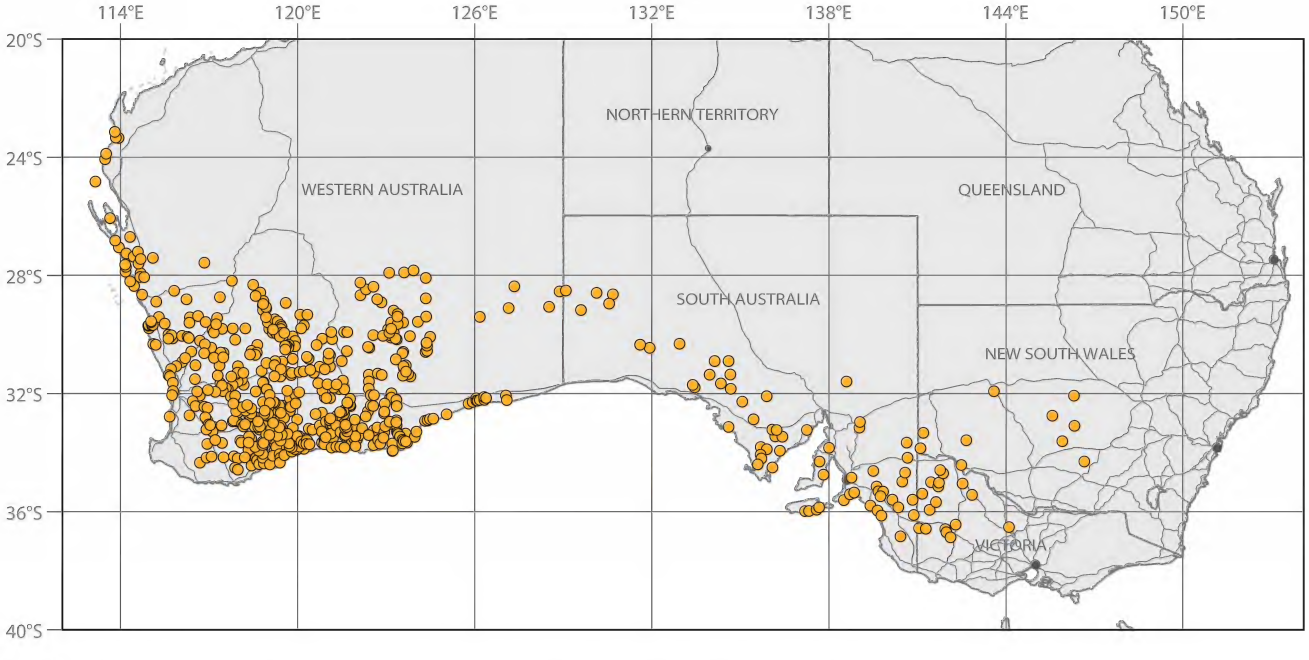

Fig. 1. Natural distribution of *Eucalyptus* ser. *Porantherae* taxa in southern Australia.

its glabrous juvenile leaves, its adult leaves (when present) that mature to be glossy and green, its axillary, 7+-flowered inflorescences, its relatively small but numerous flower buds, its white staminal filaments, its summer flowering period, and its relatively small fruits with a pale-coloured, level to descending disc.

The series is also notable for its distinct and often conspicuous vegetative dimorphism. Although all eucalypts are vegetatively dimorphic, it is more pronounced in some groups than others, with *Eucalyptus* ser. *Porantherae* being amongst the most manifest, perhaps only rivalled within *E.* subg. *Symphyomyrtus* by the distantly related, eastern Australian *E.* sect. *Maidenaria* L.D.Pryor & L.A.S. Johnson ex Brooker. Juvenile morphology in *E.* ser. *Porantherae* has long been recognised to be both diverse and powerful in discriminating taxa (Brooker 1979, 1988). As in *E.* sect. *Maidenaria*, a number of species in *E.* ser. *Porantherae* are cryptic in the reproductively mature phase and can only be identified from related species when in the juvenile growth phase.

Eucalyptus ser. *Porantherae* is distributed from the west coast from Coral Bay to south of Perth in Western Australia, eastwards through South Australia to the Condobolin to Nymagee area in New South Wales and to near Bendigo in Victoria (Fig. 1). By far the greatest taxonomic diversity is in southern W.A., where 22 of the 23 species occur, 21 of which are endemic. Only two species occur in S.A. (*E. leptophylla* and *E. omissa*) and only one in N.S.W. and Vic. (*E. leptophylla*). All taxa occur in well-drained sandy soils, and none grow naturally on heavy clays. A number of species commonly occur on somewhat saline sites in low-lying areas or around ephemeral salt lakes, e.g. *E. ecdysiastes* K.D.Hill ex D.Nicolle & M.E.French, *E. kumarlensis*, *E. lunata* and *E. salicola*. Several species grow on well-drained sands overlying limestone on front-line coastal sites where exposed to strong, salt-laden winds, e.g. *E. foecunda* and *E. fruticosa*. A number of species are considered to be at some threat of potential extinction due to their rarity and proximity to urbanisation and mineral extraction (*E. foecunda* subsp. *foecunda*), or historical vegetation clearance and habitat fragmentation (*E. efflorescens* L.A.S.Johnson & K.D.Hill ex D.Nicolle & M.E.French and *E. dissimulata* subsp. *plauta* L.A.S.Johnson & K.D.Hill ex D.Nicolle & M.E.French), or increasing fire frequency and intensity associated with climate change (the obligate seeder species *E. kumarlensis* and *E. salicola*).

A number of species in the series have been commonly cultivated due to their ornamental appeal and their use in the floriculture industry, including *Eucalyptus albida* Maiden & Blakely, *E. dissimulata*, *E. formanii*, *E. lunata* and *E. uncinata* (Nicolle 2016). Other species (e.g. *E. salicola*) that grow around ephemeral salt lakes on low-lying, saline areas, are presumably very salt-tolerant and may be suitable for dryland salinity mitigation and rehabilitation.

Methods

Extensive field observations and herbarium collections of wild populations of all taxa in the series have been made by us over the past 30 years. All taxa of *Eucalyptus* ser. *Porantherae* have been examined and collected by us in the field, in many cases with an accompanying seed collection, and including cited hybrids and intergrades. Field studies of wild populations over a number of decades have allowed the observation of habit and bark characteristics, habitat preferences, and life histories of taxa following destructive wildfire events. Descriptive data for the new taxa include many field-recorded characteristics including habit and bark characteristics, and leaf colour and sheen. Descriptive data have also been taken from both dried herbarium specimens and cultivated live material. Adult leaf tertiary venation densities and oil gland frequencies follow the definitions in Brooker & Nicolle (2013).

Juvenile morphology within the series is diverse and informative, and we have found it very useful in identifying all taxa, and essential in determining some. Field study has allowed the observation and collection of seedlings and coppice regrowth and, more importantly, the collection of seeds that accompany many of our herbarium specimens. Within *Eucalyptus* ser. *Porantherae*, we have cultivated outdoor-grown seedlings (or seedlots – multiple seedlings from a single adult plant) from over 350 of our field-collected herbarium specimens. These have been supplemented with glasshouse-grown seedlings grown by others in CANB and NSW from approximately 90 herbarium specimens, mainly those of Ian Brooker and Andrew Slee. Juvenile morphology has also been assessed using wild-collected seedlings and lignotuber coppice. We have included figures of representative seedling material (live or preserved material) for all species in the series.

Because of the importance of juvenile morphology in discriminating taxa within the series, we are here defining the different growth phases as used in this taxonomic revision:

- *Juvenile:* the initial growth phase of the leaves occurring before adult growth, including seedling and coppice growth (see below). The juvenile growth phase sometimes extends to the reproductively mature plant, as often seen in *E. efflorescens*, *E. fruticosa* and *E. omissa*.
- *Seedlings:* The initial growth phase of the leaves when grown from seed, not including the cotyledons. The seedling growth phase extends for as few as 5 to 6 nodes but more commonly for 10 to 20 nodes or more. The first few pairs of leaves after the cotyledons are atypical, being smaller and narrower than later leaves. We have typically assessed seedling leaf characteristics between nodes 6 and 15.
- *Coppice:* The initial growth phase of the leaves when resprouting from epicormic buds in the lignotuber (or sometimes from epicormic buds in the trunk/

stem) of a mature individual. Coppice growth has leaf phyllotaxis, shape, colour, and pruinosity that is very similar to seedling growth but differs in that the nodes are often slightly more spaced, and the leaves are sometimes slightly larger.

- *Intermediate:* The transitional growth phase of the leaves between that of juvenile (including seedling and coppice growth) and adult leaves.
- *Adult:* The final growth phase of the leaves, typified in *E.* ser. *Porantherae* by leaves that are disjunct, petiolate, generally linear to broad-lanceolate, and green and non-pruinose. Most (but not all) taxa are reproductively mature only in the adult growth phase.

Over 90 of the seedlots grown from seed accompanying our herbarium collections have subsequently been grown under uniform conditions at Currency Creek Arboretum in South Australia (see www.dn.com.au/Currency_Creek_Arboretum.html), generally with four individuals/siblings planted per seedlot (i.e. approximately 360 individuals planted in total). Many of these planted individuals have now reached maturity (flowered) at the arboretum. Some of the descriptive data for the new taxa have been taken from seedling and adult characteristics obtained from these cultivated plants. Ongoing observations of cultivated plants have enabled the study of developmental morphology in the taxa, including lignotuber development, bark ontogeny, leaf ontogeny related to plant maturity, seasonal leaf-colour variation, flower bud development, and flowering times.

All material of *Eucalyptus* ser. *Porantherae* incorporated in the collections at PERTH and AD have been examined, including type material. Selected material from CANB and NSW, as well as digitised images of type specimens from other herbaria, have also been examined where necessary. Because juvenile morphology within the series is so informative, and essential to determine the identity of some taxa, we have preferentially cited adult specimens where seedlings have been grown or where seedlings or juvenile coppice growth has been observed and collected in the field. This has meant that the majority of cited specimens are our own collections, supplemented with collections including seedlings or coppice growth collected by others, especially those of Andrew Slee from CANB. We have been broader in the selection of cited specimens for taxa that are well-defined in their adult growth phase, such as *E. formanii* and *E. albida*. Similarly, in the distribution maps, we have only plotted populations where we have been able to verify the identity of the adult material using corresponding juvenile material, either by growing seedlings from seed collected from the adult specimen, or by observing/collecting coppice material from the same adult plant. We have generally only provided figures of adult material (habit, bark, foliage, flowers, fruits) for taxa where the existing literature does not illustrate these features.

We have provided a description for *Eucalyptus* ser. *Porantherae*, with morphology common to all taxa in the series, and these are not duplicated in each species description. Likewise, morphological characters common to a species are not duplicated in the description for each subspecies. All cited specimens are listed from west to east or from north to south, depending on the shape of the taxon's distribution.

In applying taxonomic category (rank) to terminal taxa, we have considered the morphological distinctiveness of each taxon and the taxon's ability to interbreed with other taxa. We maintain that subspecies within a species are incompletely or more recently evolved (i.e. not fully speciated), and as such are generally less distinctive and often have geographical zones of intergradation with related taxa.

The notes for each taxon generally indicate its most closely related or superficially similar taxa. Hybrids and intergrades involving taxa within *Eucalyptus* ser. *Porantherae* are listed as an appendix following the taxon treatments. Hybrids, hybrid swarms and intergrades, in the context of this revision, are defined as such:

- A *hybrid* is an individual having morphology intermediate between two parental taxa and presumed to be of F1 origin, occurring as a single plant or rare isolated plants, usually in a vegetation community in which both putative parental taxa are present.
- A *hybrid swarm* consists of multiple individuals displaying a range of variation that is generally intermediate between the putative parental taxa, indicating probable backcrossing between hybrid individuals and one or both of the parental taxa.
- An *intergrade* is defined as an individual having morphology that is intermediate between two taxa, occurring in a population with many other individuals of similar morphology, but not associated with the two taxa with which it appears intermediate. Intergrades may occur over relatively substantial areas that are generally intermediate in distribution between the two taxa with which it appears intermediate, and may show gradational morphological variation over that area, grading from one taxon to the other through the intergrading population(s).

All taxa in the series are fecund, woody, perennial mallees or trees, which are usually not at risk from specimen collection, flower harvesting and related activities, although some taxa in the series are at risk from large-scale landscape modifications including climate change, mining, and changing fire regimes. Even though we believe that obfuscating locality data will not necessarily result in any conservation benefit for these taxa, we understand that this is a requirement for taxa of conservation concern (defined as being at least 'Near Threatened' using IUCN categories and/or being listed as a threatened or priority taxon in Western Australia). As such, location data of these species and

subspecies, including hybrids and intergrades, have been partly obfuscated and generalised. Field-recorded GPS coordinates have been omitted from the location of all cited specimens (where present), including the types of some of the new taxa.

Prior to this revision, only two of the taxa described herein (*Eucalyptus formanii* and *E. efflorescens*, the latter under the name *E. leptophylla* var. *floribunda*) were listed on the *Threatened and Priority Flora list for Western Australia* (Smith & Jones 2018). However, following this revision, a number of taxa are suggested for listing in W.A., on the basis of their distribution and threatening processes, particularly *E. kumarlensis*, *E. dissimulata* subsp. *plauta* and *E. uncinata* subsp. *crassifolia* D.Nicolle & M.E.French. We have provided the IUCN Red List category for species that were assessed in 2020 (IUCN 2020, based on Fensham *et al.* 2020). However, we do not agree with the category applied to many species in that particular assessment, due to its over-reliance on using historical vegetation clearance in its assessment, while largely ignoring current and future threatening processes such as climate change and associated changes in fire intensity and frequency.

Taxonomy

Eucalyptus ser. *Porantherae* Benth.

Fl. Austral. 3: 191, 213 (1867). — *Eucalyptus* sect. *Porantherae* (Benth.) Nied. in Engl. & Prantl, *Nat. Pflanzenfam.* III(7): 92 (1893). — **Lectotype:** *Eucalyptus uncinata* Turcz., *fide* Chippend., *Fl. Australia* 19: 503 (1988).

Eucalyptus ser. *Fruticosae* Blakely, *Key Eucalypts* 53, 221 (1934). — **Lectotype:** *Eucalyptus leptophylla* F.Muell. ex Miq., *fide* Brooker, *Austral. Syst. Bot.* 13(1): 108 (2000).

Eucalyptus subser. *Ovatae* Brooker, *Austral. Syst. Bot.* 13(1): 108 (2000). — **Type:** *Eucalyptus leptophylla* F.Muell. ex Miq.

Eucalyptus subser. *Longiores* Brooker, *Austral. Syst. Bot.* 13(1): 108 (2000). — **Type:** *Eucalyptus foecunda* Schauer.

Branchlets lacking pith glands. *Cotyledons* bisected. *Adult leaves* disjunct, petiolate, concolorous. *Inflorescences* axillary, unbranched, held erect, 7–15-flowered. *Flowers* white, occurring en masse in summer, staminal filaments slender, all fertile, inflexed or irregularly flexed in bud; anthers small, adnate, basifixed; ovules in 4 vertical rows on each placenta. *Fruits* with a finally descending, whitish disc. *Seeds* grey to pale red-brown, compressed ovoid, smooth or with a very shallow reticulum, 1–2 mm long.

Diagnostic characters. Distinguished within *Eucalyptus* by the absence of branchlet pith glands, bisected cotyledons, disjunct, petiolate, concolorous adult leaves, axillary, erect-held inflorescences, white flowers occurring on mass in summer, small, adnate anthers, ovules in 4 vertical rows on each placenta, fruits with a descending whitish disc, and ± smooth seeds.

Notes. A total of 23 species and 11 subspecies (incl. 5 autonymous subspecies) are here recognised in the series. Brooker (2000) recognised two subseries in *E.* ser. *Porantherae*. While the series can be loosely divided into a number of species-groups (e.g. *E. albida* as one group and all other taxa as another), we consider that the distinction between these groups is not sufficient to warrant their recognition as subseries. Within the two subseries recognised by Brooker (2000), there are instances of intergrading populations between species that Brooker placed in those subseries. In any case, we regard the type species for each of Brooker's two subseries to fall into the same natural group, and thus these subseries are not recognised here.

Key to the taxa of *Eucalyptus* series *Porantherae*

1. Trees, usually non-lignotuberous and non-resprouting; bark smooth and decorticating throughout
- **2.** Seedling leaf length-width ratio >6:1, green, non-pruinose; Kumarl to Lort River area in W.A. . . . . **3. *E. kumarlensis***
- **2:** Seedling leaf length-width ratio <2:1, greyish, pruinose; widespread in wheatbelt and southern goldfields in W.A. . . . . **12. *E. salicola***

1: Lignotuberous mallees; bark smooth and decorticating or partly rough and non-decorticating
- **3.** Buds and fruits sessile and crowded; seedling leaf length-width ratio 0.6–1.4:1, often connate
  - **4.** Fruits 3–5 mm diam.; juvenile leaves consistently connate; bark rough on lower trunks; Esperance plains . . . . . **22. *E. connexa***
  - **4:** Fruits 5–8.5 mm diam.; juvenile leaves connate or free; bark smooth throughout or rough on lower trunks; widespread [*E. uncinata*]
    - **5.** Adult leaves <1 mm thick; peduncles 3.5–11 mm long; buds 6–9 mm long; widespread in southern W.A. . . . . **21a. *E. uncinata* subsp. *uncinata***
    - **5:** Adult leaves to 1.5 mm thick; peduncles 10–20 mm long; buds 8–13 mm long; northern Ravensthorpe Range in W.A. . . . . **21b. *E. uncinata* subsp. *crassifolia***

3: Buds and fruits pedicellate, not crowded; seedling leaf length-width ratio 1–40:1, never connate

6. Adult leaves with few or no oil glands visible (in fresh leaves using transmitted light) [*E. rigidula*]

7. Seedling leaves ovate or elliptic to broad-lanceolate (length-width ratio <5.5:1); Kalbarri area southwards to the Lake Grace area and eastwards to the Kalgoorlie area . . . . . **17a. *E. rigidula* subsp. *rigidula***

7: Seedling leaves linear to lanceolate (length-width ratio >5.5:1); Mount Magnet area eastwards to the Great Victoria Desert and southwards to the Balladonia area

8. Adult leaves 6–18 mm wide (length-width ratio 5–10:1); peduncles 6–15 mm long, pedicels 2–5 mm long; fruits 4–5 mm diam.; Mount Magnet area eastwards to the Great Victoria Desert and southwards to the Zanthus area . . . . . **17b. *E. rigidula* subsp. *interior***

8: Adult leaves 3–10 mm wide (length-width ratio 8–16:1); peduncles 2–8 mm long, pedicels 1–2.5 mm long; fruits 3–5.5 mm diam.; Fraser Range area . . **17c. *E. rigidula* subsp. *clancularia***

6: Adult leaves with numerous oil glands visible (in fresh leaves using transmitted light)

9. Seedling leaves densely-crowded; disjunct or spirally arranged; length-width ratio 4–40:1

10. Bark non-decorticating on lower trunks [*E. formanii*]

11. Adult leaves 1.5–4 mm wide (length-width ratio 16–40:1) . . . . . **1a. *E. formanii* subsp. *formanii***

11: Adult leaves 4–9 mm wide (length-width ratio 8–18:1) . . . . . **1b. *E. formanii* subsp. *circulata***

10: Bark smooth and annually decorticating throughout

12. Seedling leaves consistently pruinose, length-width ratio 4–24:1; adult leaves consistently green; Great Victoria Desert . . . . . **2. *E. plumula***

12: Seedling leaves variably pruinose, length-width ratio 4–8:1; adult leaves green to slightly blue green; wheatbelt and southern goldfields of W.A. . . . . **5. *E. olivina***

9: Seedling leaves in opposite pairs; length-width ratio 1–20:1

13. Adult leaves 1–3 (–5) mm wide; bark smooth throughout; seedling leaves linear to narrowly elliptical . . . . . **4. *E. perangusta***

13: Adult leaves (3.5–) 5–22 mm wide; bark smooth or rough, seedling leaves linear to orbicular

14. Seedling leaves linear to elliptical

15. Bark rough and non-decorticating on lower trunks

16. Adult leaves initially dull and blue-green, maturing green; south coast of W.A.

17. Seedling leaves 2–12 mm wide; buds 5.5–7 mm long; opercula rounded, 2–3 mm long (0.5–1 times as long as wide); Esperance to Israelite Bay . . . . . **19. *E. discreta***

17: Seedling leaves 4–22 mm wide; buds 6–10 mm long; opercula conical to slightly beaked, 2.5–5 mm long (1.5–2 times as long as wide); Wylie Scarp to Roe Plains . . . . . **20. *E. sinuensis***

16: Adult leaves consistently glossy and green; west coast of W.A. [*E. foecunda*]

18. Seedling leaves dull to glossy, green, non-pruinose; south from Jurien Bay . . . . . **9a. *E. foecunda* subsp. *foecunda***

18: Seedling leaves dull, grey-green, pruinose; north from Leeman . . . . . **9b. *E. foecunda* subsp. *aeolica***

15: Bark smooth and annually decorticating throughout

19. Buds 7–12 mm long × 3–6 mm wide; adult leaves 5–22 mm wide [*E. dissimulata*]

20. Adult leaves 5–15 mm wide (length-width ratio 6–11:1), glossy and green at all ages; west of Ravensthorpe . . . . . **18a. *E. dissimulata* subsp. *dissimulata***

20: Adult leaves 6–22 mm wide (length-width ratio 5–9:1), dull and blue-green initially, adding to glossy and dark green; east of Ravensthorpe . . **18b. *E. dissimulata* subsp. *plauta***

19: Buds 5–8 mm long × 2–4.5 mm wide; adult leaves 3.5–12 mm wide

21. Adult leaves dull and blue-green initially, maturing glossy and green; opercula rounded, 0.5–1 times as long as wide; Esperance to Israelite Bay area in W.A. . . . . **19. *E. discreta***

21: Adult leaves glossy and green at all ages; opercula hemispherical to beaked, 0.8–1.6 times as long as wide; southern W.A. excluding the Esperance plains, and in S.A., Vic. and N.S.W.

22. Opercula 1–1.6 times as long as wide; fruits 3–4.5 mm diam.; seedling leaves 15–50 mm long; W.A. . . . . **8. *E. latens***

22: Opercula 0.8–1.2 times as long as wide; fruits 4–5 mm diam.; seedling leaves 10–35 mm long; S.A., Vic. and N.S.W. . . . . **10. *E. leptophylla***

14: Seedling leaves ovate to orbicular or cordate

23. Bark non-decorticating on lower trunks

24. Adult leaves dull; reproductive branchlets pruinose; central wheatbelt only **15. *E. efflorescens***

24: Adult leaves glossy; reproductive branchlets usually non-pruinose; widespread

25. Sprawling mallee; fruits 5–7 mm diam.; mature canopy often composed of a mixture of juvenile, intermediate and adult leaves; Coral Bay to Horrocks on west coast of W.A. . . . . **16. *E. fruticosa***

25: Erect-stemmed mallee, fruits 3–5.5 mm diam.; mature canopy mixed or composed of adult leaves only; elsewhere in W.A. and S.A.

26. Non-decorticating bark (if present) loose; opercula rounded to slightly beaked; canopy often composed partly of juvenile leaves; Great Victoria Desert . . . . . **11. *E. omissa***

26: Non-decorticating bark firm; opercula sharply pointed; canopy composed entirely of adult leaves; widespread . . . . . **14. *E. horistes***

23: Bark smooth and annually decorticating throughout

27. Fruits 5–7 mm diam.; style twisted in bud; opercula blunt-tipped . . . . . **23. *E. albida***

27: Fruits 2.5–5 mm diam.; style straight; opercula acute or blunt-tipped

28. Opercula rounded to slightly beaked; eastern states and Great Victoria Desert of W.A.

29. Juvenile leaves narrowly elliptic to ovate, variably pruinose; S.A., Vic. and N.S.W., south and east of Great Victoria Desert . . . . . **10. *E. leptophylla***

29: Juvenile leaves orbicular to cordate, consistently pruinose; Great Victoria Desert in W.A. and S.A. . . . . **11. *E. omissa***

28: Opercula acute-tipped; wheatbelt to western Great Victoria Desert in W.A.

30. Seedling leaves ovate, non-pruinose except for new growth . . . . . **6. *E. austrina***

30: Seedling leaves ovate to orbicular or cordate, pruinose

31. Seedling internodes 2–5 mm apart; adult leaves 1.5–5 (–7) mm wide (length-width ratio 10–23:1) . . . . . **7. *E. lunata***

31: Seedling internodes 8-20 mm apart; adult leaves 4–12 mm wide (length-width ratio 7–12:1) . . . . . **13. *E. ecdysiastes***

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1. *Eucalyptus formanii* C.A.Gardner

J. Roy. Soc. Western Australia 27: 186 (1942). — **Type citation:** "Hab. in distr. Coolgardie ad fines boreali prope 'Die Hardy Range,' a vico Southern Cross, 175 km. septentrionem versus in fruticetis apertis arenosis, *F.G. Forman* et *R.S. Matheson*, July, 1940". **Holotype:** Die Hardy Range, near Mt Jackson, July 1940, *F.G. Forman & R.S. Matheson s.n.* (PERTH01151010).

Mallee to 14 m tall, sometimes becoming tree-like; lignotuber present, lignotuber resprouter (Nicolle 2006). *Bark* persistent on lower third to half of trunks (typically up to 1.5–5 m), fibrous, finely-fissured, grey, then smooth above, decorticating annually in strips, grey over tan to cream. *Branchlets* non-pruinose. *Seedling leaves* opposite for a few nodes then becoming disjunct and apparently spirally-arranged for numerous nodes, nodes <1–8 (–14) mm apart, sessile, linear to very narrowly spathulate, 12–60 mm long × 1–5 mm wide, length:width ratio typically 8–20 (–40):1, concolorous, dull, grey-green to grey, typically pruinose. *Coppice leaves* similar but typically larger and more spaced. *Mature crown* composed entirely of adult leaves. *Adult leaves* with petioles 2–10 mm long, lamina linear to narrow-lanceolate, 35–85 mm long × 1.5–9 mm wide, length:width ratio typically 8–35:1, glossy, green, non-pruinose; tertiary venation moderate to dense; oil glands scattered to numerous, connected to vein network (intersectional glands). *Inflorescences* 7–11-flowered; peduncles terete, 5–10 mm long; pedicels 2–5 mm long. *Flower buds* diamond-shaped to fusiform, 6–9 mm long × 2–4 mm diam.; opercula slightly beaked to beaked, apiculate, 4–6 mm long, length:width ratio typically 1.4–1.8:1. *Fruits* cupular, 3–4 mm long × 3–4 mm diam.; disc ± level to descending; valves 3 or 4, around rim. **Fig. 2.**

Diagnostic characters. Distinguished within *E.* ser. *Porantherae* by the following combination of characters: Lignotuberous mallee. Bark persistent on lower trunks. Branchlets non-pruinose. Seedling leaves becoming spirally-arranged, crowded, linear (length:width ratio

Fig. 2. *Eucalyptus formanii* habitat and habit. **A** subsp. *formanii* (*D. Nicolle 5693 & M.E. French*, near Olby Rock, W.A.); **B** subsp. *circulata* (*D. Nicolle 7291 & M.E. French*, S of Metzke Find mine, W.A.).

8–40:1), greyish, pruinose (Fig. 3). Adult leaves linear to narrow-lanceolate (length:width ratio 8–35:1), glossy. Pedicels distinct. Opercula beaked. Fruits cupular.

Distribution and habitat. Endemic to W.A., where it occurs from near Lake Barlee and south-west of Ularring in the north, southwards to the Helena and Aurora Ranges (Fig. 4). It grows on level terrain in orange to red sandy loam, or on stony hillslopes and ridges, in open mallee shrubland or mixed mallee woodland.

Conservation status. Globally listed as 'Least Concern' on the IUCN Red List of Threatened Species (IUCN

Fig. 3. *Eucalyptus formanii* seedlings. **A** subsp. *formanii* (F1 of *D. Nicolle 1567*, just SW of Pigeon Rocks, W.A.); **B** subsp. *formanii* (F1 of *D. Nicolle 5693 & M.E. French*, near Olby Rock, W.A.); **C** subsp. *circulata* (F1 of *D. Nicolle 5672 & M.E. French*, NW side of Helena and Aurora Ranges, W.A.); **D** subsp. *circulata* (F1 of *D. Nicolle 5684 & M.E. French*, between Hunt Range and Mount Manning N.R., W.A.).

2020). Considering its known distribution, life cycle, and threats, we believe that an IUCN Red List category of 'Near Threatened' is more appropriate for the species.

Currently listed as Priority 4 under Conservation Codes for Western Australian Flora (Smith & Jones 2018). We concur with this assessment. It is not clear if the concept of the species as recognised by Smith & Jones (2018) includes both subspp. *formanii* and *circulata*, or only subsp. *formanii*.

We below suggest conservation codes for the two subspecies of *E. formanii* using IUCN and Conservation Codes for Western Australian Flora assessment methodology.

Notes. *Eucalyptus formanii* is a well-defined species. It is closely related to *E. plumula*, which differs most notably in its completely smooth, shedding bark, its less prominently beaked opercula and its smaller fruits. *Eucalyptus plumula* also tends to have slightly broader seedling, juvenile and adult leaves, although the size of these features overlap with those of *E. formanii* subsp. *circulata* D.Nicolle & M.E.French.

Two geographic subspecies are recognised in *E. formanii*, differing in the width of their leaves.

1a. *Eucalyptus formanii* C.A.Gardner subsp. *formanii*

Adult leaves linear, 1.5–4 mm wide, length:width ratio 16–40:1.

Diagnostic characters. Distinguished from *E. formanii* subsp. *circulata* by its narrower intermediate and adult leaves.

Illustrations. M.I.H. Brooker & D.A. Kleinig, *Field Guide Eucalypts* 2: 309 (1990); 2nd edn, 2: 309 (2001); 3rd edn, 2: 283 (2016).

Distribution and habitat. Endemic to W.A., where it is restricted to a small area centred on the Die Hardy Range and Yokradine Hills in Western Australia, in an area bounded by (but not extending to) old Diemals homestead, Mt Jackson and the Mt Manning Range (Fig. 4). It grows on level terrain in red sandy loam, sometimes with ironstone, in mallee shrubland with a variety of other eucalypts including *Eucalyptus corrugata*,

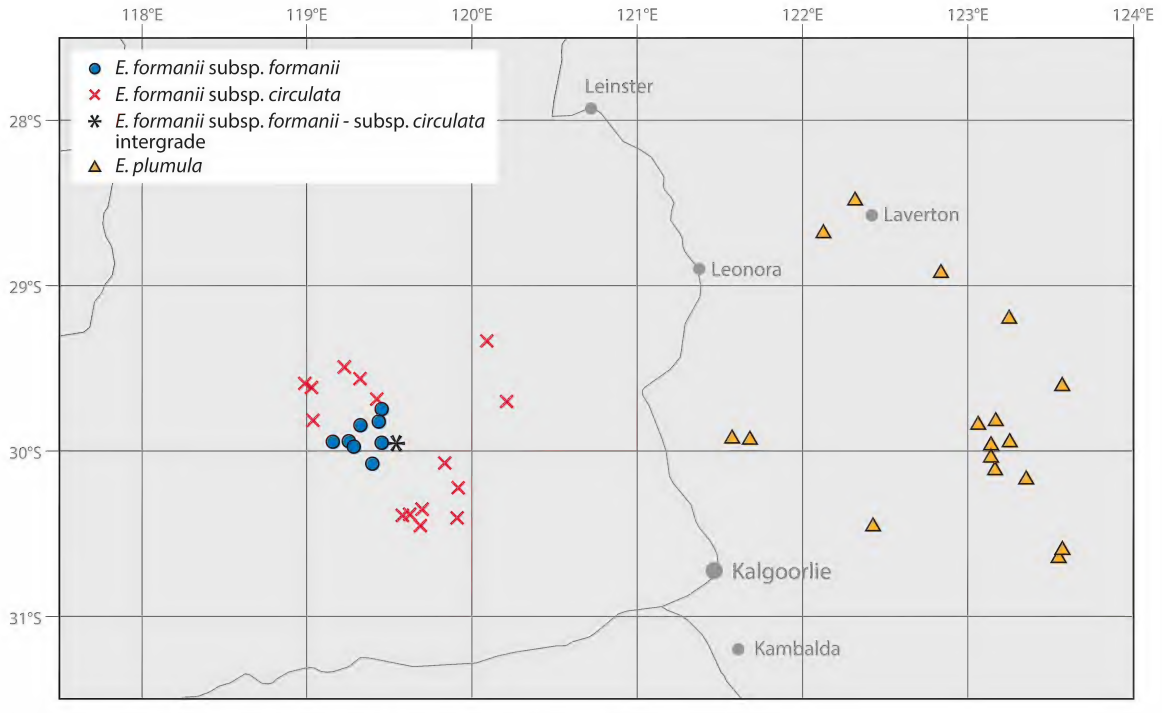

Fig. 4. Distribution of *Eucalyptus formanii* and *E. plumula* in Western Australia.

E. ewartiana, *E. kochii* subsp. *amaryssia*, *E. loxophleba* subsp. *lissophloia* and *E. moderata*.

Conservation status. The subspecies is not yet assessed under the IUCN Red List of Threatened Species (IUCN 2020). Considering its known distribution, life cycle, and threats, we believe that an IUCN Red List category of 'Vulnerable' is appropriate for the subspecies.

Eucalyptus formanii is currently listed as Priority 4 under Conservation Codes for Western Australian Flora (Smith & Jones 2018). It is not clear if the concept of the species as recognised by Smith & Jones (2018) includes both subspp. *formanii* and *circulata*, or only subsp. *formanii*. *Eucalyptus formanii* subsp. *formanii* has been recorded from Mount Manning Nature Reserve and the north-western section of Mount Manning – Helena and Aurora Ranges Conservation Park. We recommend that the conservation status of this subspecies be assessed in Western Australia, and suggest an interim code of Priority 3 (Poorly-known species) using Conservation Codes for Western Australian Flora and Fauna criteria under the *Biodiversity Conservation Act 2016*.

Common names. Die Hardy Mallee (Slee *et al.* 2006; Brooker & Kleinig 2016), Forman's Gum (Brooker & Kleinig 2016).

Notes. The distribution of *E. formanii* subsp. *formanii* is much more restricted than previously recognised for *E. formanii* in the broad sense. The subspecies is distinctive in the field due to its canopy of very narrow, linear adult leaves. The broader-leaved, more widespread subsp. *circulata* occurs to the north, east and south of subsp. *formanii*.

Selected specimens

WESTERN AUSTRALIA (west to east). Clampton-Pigeon Rocks Rd, W of Die Hardy Ranges (Ra.), N of Bullfinch, 2 Dec. 2016, *M.E. French 2909* (PERTH); just SW of Pigeon Rocks, 20 Sep. 1995, *D. Nicolle 1567* (AD); Pigeon Rocks to Unnamed Ra. track, c. 4 km N of Unnamed Ra., 23 June 1990, *F.H. & M.P. Mollemans 2959* (CANB, PERTH); Red Boomerang Prospect, c. 20 km S of Diemals in the Johnston Ra., 6 Feb. 2008, *S. Reiffer SRE 25* (PERTH); track to Windarling Airstrip, c. 130 km NE of Southern Cross, 12 Dec. 2003, *S. McNee LCH 8644* (PERTH); near Olby Rock, between Mt Manning Ra. and Die Hardy Ra., 22 July 2010, *D. Nicolle 5693 & M.E. French* (AD); c. 28 km S Diemals/Evanston turnoff, Die Hardy Ra., Austin Botanical District, 9 Nov. 1993, *L. Sweedman LCH S 3012* (PERTH); c. 6 km S of the Diemals-Menzies Rd, towards Bullfinch (Near Evanston Mine), 23 Oct. 1978, *L.D. Pryor & J.D. Briggs 148* (CANB, PERTH); between Die Hardy Ra. and Mt Manning Ra., 17 Mar. 1978, *A.S. George 15124* (PERTH).

1b. *Eucalyptus formanii* subsp. *circulata* D.Nicolle & M.E.French, *subsp. nov.*

Holotypus: Western Australia, NW side of Helena and Aurora Ranges, 20 July 2010, *D. Nicolle 5672 & M.E. French* (PERTH). **Isotypus:** AD241388.

Adult leaves linear to narrow-lanceolate, 4–9 mm wide, length:width ratio 8–18:1.

Diagnostic characters. Distinguished from *E. formanii* subsp. *formanii* by its relatively broad intermediate and adult leaves.

Distribution and habitat. Endemic to W.A., where it occurs from near Lake Barlee and Metzke Find in the north, southwards to the Helena and Aurora Ranges, to the north, east, and south of the distribution of subsp. *formanii* (Fig. 4). It grows on level terrain in orange to red sandy loam, or on stony hillslopes and ridges (e.g. on the Helena and Aurora Ranges). The subspecies grows in open mallee shrubland or mixed mallee woodland with a variety of associates including *Callitris glaucophylla*, *Eucalyptus comitae-vallis*, *E. concinna*, *E. corrugata*, *E. ebbanoensis*, *E. kochii* subsp. *amaryssia*, *E. leptopoda* subspp. *elevata* and *subluta*, *E. longissima*, *E. loxophleba* subspp. *lissophloia* and *supralaevis*, *E. moderata*, *E. salmonophloia* and *E. transcontinentalis*.

Conservation status. The subspecies is not yet assessed under the IUCN Red List of Threatened Species (IUCN 2020). Considering its known distribution, life cycle, and threats, we believe that an IUCN Red List category of 'Vulnerable' is appropriate for the subspecies.

Eucalyptus formanii is currently listed as Priority 4 under Conservation Codes for Western Australian Flora (Smith & Jones 2018). It is not clear if the concept of the species as recognised by Smith & Jones (2018) includes both subspp. *formanii* and *circulata*, or only subsp. *formanii*. *Eucalyptus formanii* subsp. *circulata* has been recorded from Mount Manning Nature Reserve and Mount Manning – Helena and Aurora Ranges Conservation Park. We recommend that the conservation status of this subspecies be assessed in Western Australia, and suggest an interim code of Priority 4 (Rare, Near Threatened and other species in need of monitoring) using Conservation Codes for Western Australian Flora and Fauna criteria under the *Biodiversity Conservation Act 2016*.

Etymology. The epithet is from the Latin *circulatus* (form a circle), referring to its ring-like distribution around the more restricted distribution of subsp. *formanii*.

Notes. The distribution of subsp. *circulata* occurs both to the north and south of the narrower-leaved, more restricted subsp. *formanii*. The two subspecies appear to be well-defined. A narrow intergrading zone extending over several kilometres has been observed approximately 12 km east of the Bullfinch-Evanston Road at the Die Hardy Range towards the Mount Manning Range.

Adult material of *E. formanii* subsp. *circulata* is indistinguishable from *E. horistes*, although the seedling and coppice (juvenile) leaves of the two species are quite different, being well-spaced, arranged in opposite pairs, and ovate to orbicular in shape in *E. horistes*. Juvenile leaves are often present as coppice shoots on the trunks and branches of *E. formanii*, enabling immediate distinction from *E. horistes*. Interestingly, *E. formanii* appears to geographically replace the more widely distributed *E. horistes* in the Lake Barlee to the Helena and Aurora Ranges region.

Selected specimens

WESTERN AUSTRALIA (west to east). Sandalwood cutter's track (tk), N of Diemals to Bimbijy tk, 13 May 2017, *D. Nicolle 7304 & M.E. French* (PERTH); c. 123 km S of the road junction at Youanmi on the Lake Barlee Rd, 23 July 1999, *J.R. Connors 1046 & D. Nicolle* (CANB, NSW, PERTH); c. 21 km N of Diemals on Youanmi Rd, Austin District, 25 Nov. 1986, *K. Hill 2609 & L.A.S. Johnson* (CANB, MEL, PERTH); SW Lake Barlee peninsula tk, Diemals Stn, 27 Aug. 2020, *M.E. French 3379* (PERTH); c. 13 km E of Diemals Homestead, 22 Oct. 1978, *L.D. Pryor & J.D. Briggs 145* (CANB, PERTH); 105 miles W of Menzies, 11 Feb. 1970, *M.I.H. Brooker 2453* (PERTH); W of Helena and Aurora Ra. on Mt Jackson tk, 17 May 2008, *M.E. French 2086* (PERTH); near S end of Helena and Aurora Ra., c. 49 km NNE of Koolyanobbing, 7 Nov. 2000, *B.J. Lepschi & L.A. Craven 4576* (CANB, PERTH); main ridge of Helena and Aurora Ra., 20 Jul. 2010, *D. Nicolle 5676 & M.E. French* (AD, PERTH); on ridgetop Helena and Aurora Ra., c. 8 km NE Bungalbin Hill, 25 July 1995, *N. Gibson & M. Lyons 3763* (PERTH); between Hunt Ra. and Mount Manning Nature Reserve (N.R.), 21 July 2010, *D. Nicolle 5684 & M.E. French* (AD, CANB, PERTH); S of Hunt Ra. on tk to Jaurdi Stn, NE of Koolyanobbing, 21 May 2020, *M.E. French 3344* (PERTH); near Mt Dimer, NE of Koolyanobbing, 21 May 2020, *M.E. French 3347* (PERTH); S of Metzke Find mine, 11 May 2017, *D. Nicolle 7291 & M.E. French* (PERTH); N of Evanston Menzies Rd, W of Menzies, 7 Oct. 2020, *M.E. French 3420* (PERTH).

2. *Eucalyptus plumula* D.Nicolle & M.E.French, *sp. nov.*

Holotypus: Western Australia, c. 61 km SE of Laverton on the Mount Dennis road, 17 July 1999, *J.R. Connors 1004 & D. Nicolle* (PERTH06127460). **Isotypi:** CANB512704; NSW521045.

Eucalyptus sp. S: Brooker & Kleinig, *Field Guide Eucalypts* 2: 310 (1990); *Ed. 2*, 2: 310 (2001).

Eucalyptus sp. Undulans (*J.R. Connors 1004 & D. Nicolle*): Slee *et al.*, *Euclid: Eucalypts Austral. Ed. 3* (2006).

Eucalyptus sp. Lake Minigwal (*D. Nicolle 2720 & J.R. Connors*): D.Nicolle *et al.*, *Nuytsia* 22(3): 104 (2012).

Eucalyptus sp. Mulga Rock (*K.D. Hill & L.A.S. Johnson KH 2668*): D.Nicolle *et al.*, *Nuytsia* 22(3): 104 (2012).

Eucalyptus sp. 'Mulga Rock': Brooker & Kleinig, *Field Guide Eucalypts Ed. 3*, 2: 284 (2016).

Mallee to 10 m tall; lignotuber present, lignotuber resprouter (Nicolle 2006). *Bark* smooth throughout, decorticating annually in strips, grey over tan to cream, occasionally with a short stocking of loose, non-shedding bark. *Branchlets* non-pruinose. *Seedling leaves* opposite for a few nodes then becoming disjunct and apparently spirally-arranged on nodes 1.5–12 mm apart, sessile, linear to narrowly elliptic, 14–70 mm long × 1–7 (–10) mm wide, length:width ratio typically 4–14 (–24):1, concolorous, dull, grey-green to grey, typically pruinose. *Coppice leaves* similar but typically larger and more spaced. *Mature crown* composed entirely of adult leaves. *Adult leaves* with petioles

5–10 mm long, lamina linear to narrow-lanceolate, 50–90 mm long × 4–10 mm wide, length:width ratio typically 8–16:1, glossy, green, non-pruinose; tertiary venation dense; oil glands scattered, connected to vein network (intersectional glands). *Inflorescences* 7–13-flowered; peduncles slightly angular in cross section, 5–10 mm long; pedicels 2–4 mm long. *Flower buds* diamond-shaped to fusiform, 6–8 mm long × 2–3 mm diam.; opercula sharply conical to beaked, 4–5 mm long, length:width ratio typically 1.4–1.8:1. *Fruits* cupular to truncate-globose, 4–4.5 mm long × 3–5 mm diam.; disc ± level to descending; valves 3 or 4, around rim level or below. **Fig. 5.**

Diagnostic characters. Distinguished within *E.* ser. *Porantherae* by the following combination of characters: Lignotuberous mallee. Bark smooth and shedding throughout. Branchlets non-pruinose. Seedling leaves becoming spirally-arranged, crowded, linear to narrowly elliptic (length:width ratio 4–24:1), greyish, pruinose (Fig. 6). Adult leaves linear to narrow-lanceolate (length:width ratio 8–16:1), glossy and green at all ages. Pedicels distinct. Opercula sharply conical to beaked. Fruits cupular to truncate-globose.

Illustrations. M.I.H. Brooker & D.A. Kleinig, *Field Guide Eucalypts* 2: 310, as *Eucalyptus* sp. S (1990); 2nd edn, 2: 310, as *Eucalyptus* sp. S (2001); 3rd edn, 2: 284, as *Eucalyptus* sp. 'Mulga Rock' (2016); A.V. Slee *et al.*, *EUCLID Eucalypts of Australia* CD ROM, *Eucalyptus* sp. Undulans (2006).

Distribution and habitat. Endemic to W.A., where it is restricted to the far western part of the Great Victoria Desert, from the Laverton area south-west to Goongarrie Nature Reserve and south-east to near Cundeelee, over a north-south and east-west linear range of approximately 260 km (Fig. 4). It grows on level ground in deep red to orange sand or sandy loam, in open mallee shrubland or mixed mallee-woodland, with a diversity of other eucalypt species and usually with a *Triodia* groundstorey. Associated eucalypts include *Eucalyptus comitae-vallis*, *E. concinna*, *E. ebbanoensis* subsp. *glauciramula*, *E. gongylocarpa*, *E. gypsophila*, *E. hypolaena*, *E. longissima*, *E. loxophleba* subsp. *lissophloia*, *E. mannensis* subsp. *mannensis*, *E. oleosa* subsp. *oleosa*, *E. pimpiniana*, *E. platycorys*, *E. rigidula* subsp. *interior*, *E. rosacea*, *E.* sp. Great Victoria Spring and *E. youngiana*.

Conservation status. Not yet assessed under the IUCN Red List of Threatened Species (IUCN 2020). Considering its known distribution, life cycle, and threats, we believe that an IUCN Red List category of 'Near Threatened' is appropriate for the species.

Not a listed taxon under Conservation Codes for Western Australian Flora (Smith & Jones 2018). Recorded from Goongarrie National Park and Queen Victoria Spring Nature Reserve.

Etymology. The epithet is from the Latin *plumula* (feathery), referring to fine adult foliage and especially the very fine, densely spaced, feather-like seedlings.

Fig. 5. *Eucalyptus plumula* habitat and habit (*D. Nicolle 6932 & M.E. French*, Pianto Rd, Goongarrie N.P., W.A.).

Fig. 6. *Eucalyptus plumula* seedlings. **A** F1 of *D. Nicolle 522*, N of Mulga Rockhole, W.A.; **B** F1 of *D. Nicolle 6931 & M.E. French*, Goongarrie N.P., W.A.; **C** F1 of *M.E. French 2818*, SW of Laverton, W.A.; **D** F1 of *M.E. French 2819*, NW of Laverton, W.A.

Common names. Narrow-leaved Desert Mallee (Brooker & Kleinig 1990).

Notes. *Eucalyptus plumula* is a well-defined species. It is most closely related to *E. formanii*, which differs most notably in its rough, fibrous bark on the lower half of the trunks, its more prominently beaked opercula and its slightly smaller fruits. *Eucalyptus formanii* also tends to have variably narrower seedling, intermediate and adult leaves, although the size of these features in *E. formanii* subsp. *circulata* overlap with those of *E. plumula*.

Within its distribution, *E. plumula* may be confused with *E. ecdysiastes*, although the two species are not known to grow together. *Eucalyptus ecdysiastes* differs from *E. plumula* most conspicuously in its well-spaced, ovate to orbicular seedling and juvenile leaves, and also in its broader adult leaves, its more robust buds, and its more robust fruits.

Selected specimens

WESTERN AUSTRALIA (west to east). c. 1 km N of corner in fence, Goongarrie Nat. Res., 6 May 1987, *M.I.H. Brooker 9611* (CANB, PERTH); Pianto Rd, Goongarrie National Park (N.P.), 27 Apr. 2015, *D. Nicolle 6931 & M.E. French* (AD, PERTH); Leonora-Laverton Rd, SW of Laverton, 30 Oct. 2015, *M.E. French 2818* (PERTH); Erlistoun Rd, c. 14 km from Central Rd turnoff, NW of Laverton, 30 Oct. 2015, *M.E. French 2819* (PERTH); c. 61 km by rd SE of Laverton towards Mt Dennis, Great Victoria Desert, 17 July 1999, *D. Nicolle 2720 & J.R. Connors* (AD, CANB); c. 7 km N of Mulga Rockhole, 30 Sep. 1993, *D. Nicolle 522* (PERTH); SE of Mulga Rock, Great Victoria Desert, N of Queen Victoria Spring N.R., 29 Dec. 2018, *M.E. French 3095* (PERTH); tk between old Cundeelee community and Queen Victoria Spring, 26 Oct. 2019, *D. Nicolle 7802 & M.E. French* (PERTH).

3. *Eucalyptus kumarlensis* Brooker

Nuytsia 6(3): 333, Figs 1, 2f, 3f (1988). — **Holotype:** 18 km W of highway on Lake King rd [Lake King–Norseman Rd], 12 Feb. 1985, *M.I.H. Brooker 8843* (PERTH01417908). **Isotype:** AD99101105; CANB 412821 [ex FRI]; MEL0687485; NSW350600.

Tree to 12 m tall; lignotuber absent, obligate seeder (Nicolle 2006). *Bark* smooth throughout, often somewhat glossy, silvery or grey to coppery-orange over cream or white, decorticating annually in strips, grey to white. *Branchlets* non-pruinose. *Seedling leaves* opposite for 8–18 nodes then becoming disjunct, nodes 2–20 mm apart, leaves sessile, linear to narrowly ovate

Fig. 7. *Eucalyptus kumarlensis*. **A** habit and habitat; **B** bark (both *D. Nicolle 8016 & M.E. French*, Lort River, S of Peak Charles, W.A.).

or narrowly spathulate, 13–26 mm long × 2–7 mm wide, length:width ratio typically 3.5–8:1, slightly discolorous, dull, green, non-pruinose. *Coppice leaves* similar but typically larger and more spaced. *Mature crown* composed entirely of adult leaves. *Adult leaves* with petioles 5–12 mm long, lamina lanceolate to narrow-lanceolate (to linear), 45–110 mm long × 4–14 (–18) mm wide, length:width ratio typically 7–12:1, glossy, green to dark green, non-pruinose; tertiary venation dense; oil glands numerous, connected to vein network (intersectional oil glands). *Inflorescences* 7–11-flowered; peduncles angular, 4–12 mm long; pedicels 1–3 mm long. *Flower buds* diamond-shaped to fusiform to ovoid, 6–9 mm long × 3.5–5.5 mm diam.; opercula (hemispherical to) conical (to slightly beaked), 3.5–6 mm long, length:width ratio typically 1–1.5:1. *Fruits* cupular to obconic, 3.5–6 mm long × 3.5–6 mm diam.; disc level to slightly descending; valves 3 (4), around rim level. **Fig. 7.**

Diagnostic characters. Distinguished within *E.* ser. *Porantherae* by the following combination of characters: Non-lignotuberous tree. Bark smooth and shedding throughout. Branchlets non-pruinose. Seedling leaves opposite for up to 18 nodes, linear to narrowly ovate or narrowly spathulate (length:width ratio 3.5–8:1), non-pruinose (Fig. 8). Adult leaves typically lanceolate to narrow-lanceolate (length:width ratio 7–12:1), glossy and green at all ages. Pedicels distinct. Opercula usually conical. Fruits cupular to obconic.

Illustrations. M.I.H. Brooker & D.A. Kleinig, *Field Guide Eucalypts* 2: 306 (1990); 2nd edn, 2: 306 (2001); 3rd edn, 2: 280 (2016); A.V. Slee *et al.*, *EUCLID Eucalypts of Australia* CD ROM, *Eucalyptus kumarlensis* (2006).

Distribution and habitat. Endemic to W.A., where it is restricted to a small area north of Esperance, in the Kumarl to upper Lort River area (Fig. 9). It occurs on lunettes and flats adjacent to salt lakes and near saline watercourses, where it grows in calcareous or gypseous grey-brown to red loam. It forms woodland or mixed mallee-woodland. Associated eucalypts include *Eucalyptus cylindrocarpa*, *E. delicata*, *E. diptera*, *E. eremophila*, *E. gracilis*, *E. kessellii*, *E. leptocalyx* subsp. *leptocalyx*, *E. ovularis*, *E. platycorys*, *E. quadrans*, *E. spreta*, *E. transcontinentalis*, *E. urna* and *E. valens*. Specimens recently collected by one of us (MF) from Salmon Gums Nature Reserve, also appear to be *E. kumarlensis*, however, we have not yet grown seedlings from this population to confirm its identity and have therefore not cited the specimen or mapped it in Fig. 9.

Conservation status. Globally listed as 'Near Threatened' on the IUCN Red List of Threatened Species (IUCN 2020). Considering its known distribution (which is

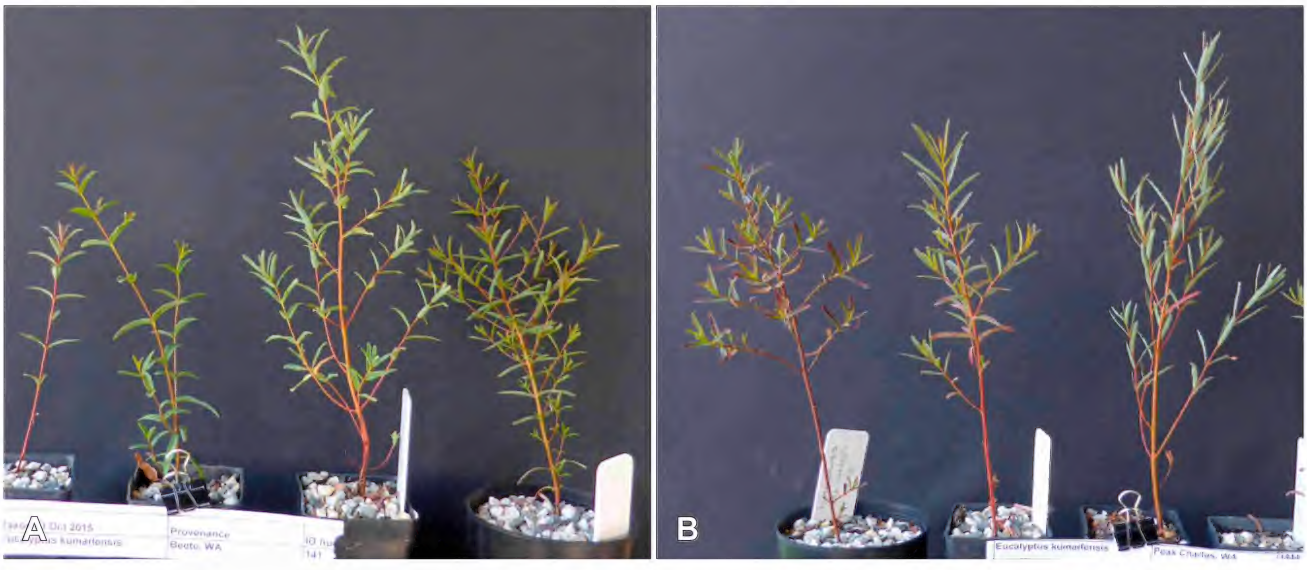

Fig. 8. *Eucalyptus kumarlensis* seedlings. **A** F1 of *D. Nicolle 141*, W of Coolgardie-Esperance Hwy on Lake King-Norseman Rd, W.A.; **B** F1 of *D. Nicolle 1844*, Field Rd, S of Peak Charles N.P., W.A.

restricted), life cycle (an obligate seeder), and threats (particularly increasing fire frequency), we believe that an IUCN Red List category of 'Endangered' would be more appropriate.

Not a listed taxon under Conservation Codes for Western Australian Flora (Smith & Jones 2018). Recorded from Peak Charles National Park. We recommend that the conservation status of this subspecies be assessed in Western Australia, and recommend an interim code of VU (Vulnerable) using Conservation Codes for Western Australian Flora and Fauna criteria under the *Biodiversity Conservation Act 2016*. The species is perhaps the most at-risk taxon in *E.* ser. *Porantherae*, especially when considering its obligate seeder regeneration strategy.

Common names. Kumarl Salmon Gum (Brooker & Kleinig 2016). The common name presumably refers to its similarity in habit and bark to that of the distantly related salmon gum, *Eucalyptus salmonophloia* F. Muell.

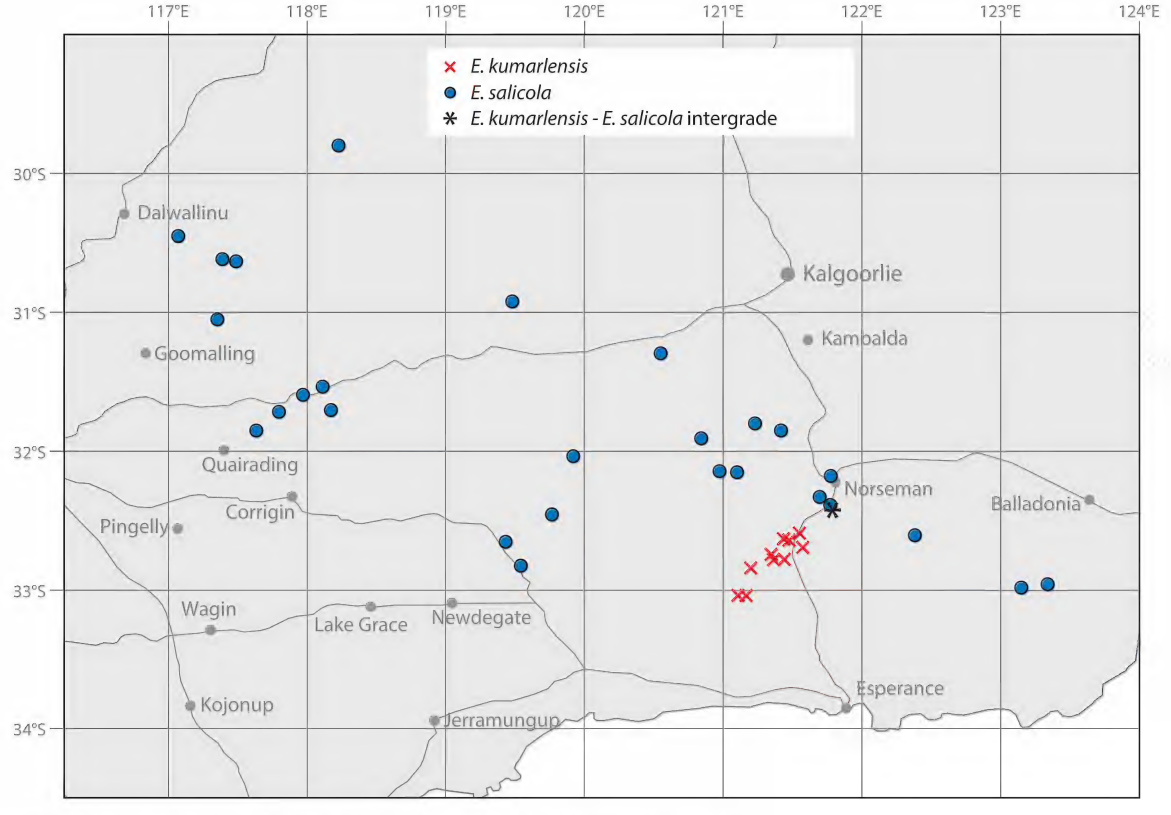

Fig. 9. Distribution of *Eucalyptus kumarlensis* and *E. salicola* in Western Australia.

Notes. *Eucalyptus kumarlensis* and *E. salicola* are the only two species in *E.* ser. *Porantherae* that have a tree (rather than a mallee) habit. Both species are mainly restricted to areas fringing ephemeral salt lakes. *Eucalyptus kumarlensis* lacks a lignotuber and is presumably fire-sensitive.

The habitat, habit and adult morphology of *E. kumarlensis* and *E. salicola* are very similar, and the two species are only reliably distinguished by their seedling morphology. Intergrades between the two species have been recorded where their distributions adjoin, at the north end of the distribution of *E. kumarlensis*, south of Norseman (e.g. *Slee 4207*).

Despite *E. kumarlensis* and *E. salicola* having the same regeneration strategy, and the presence of intergrades between the two species where their distributions adjoin, the juvenile morphology of *E. kumarlensis* suggests a closer relationship with some of the resprouter species with narrow juvenile leaves such as *E. perangusta* and *E. olivina*. *Eucalyptus kumarlensis* occurs within the wider distribution of both *E. perangusta* and *E. olivina*, but they are not sympatric, and hybrids between *E. kumarlensis* and these two species are not known.

Selected specimens

WESTERN AUSTRALIA (west to east). c. 6 km NW of Lort River crossing on Fields Rd, 13 Oct. 1998, *P.J. White 1195 & W. O'Sullivan* (AD, PERTH); Field Rd, S of Peak Charles N.P., 7 Oct. 1996, *D. Nicolle 1844* (PERTH); Field Rd, N of Lort River, 19 Jan. 2021, *D. Nicolle 8016 & M.E. French* (PERTH); Peak Charles Rd, Peak Charles N.P., 19 Jan. 2021, *D. Nicolle 8018 & M.E. French* (PERTH); c. 2 miles W of Norseman-Esperance Rd, on road to Lake King, 16 Feb. 1970, *M.I.H. Brooker 2510* (CANB, NSW, PERTH); NW of Salmon Gums, 6 Dec. 2006, *M.E. French 1825* (PERTH); c. 5 km W of Kumarl on Peak Charles rd, 7 Apr. 1985, *M.I.H. Brooker 8905* (CANB, PERTH); c. 5 km W of Hwy 1 on Kumarl-Peak Charles Rd, 8 Sep. 1999, *A.V. Slee 4212* (CANB); c. 4 km W of Hwy 1 on Norseman-Lake King Rd, 17 Sep. 1999, *A.V. Slee 4260* (CANB); W of Coolgardie-Esperance Rd on Peak Charles Rd, 6 Dec. 1992, *D. Nicolle 141* (AD); just W of Coolgardie-Esperance Rd on Peak Charles Rd, 22 Jan. 1996, *D. Nicolle 1645* (AD, PERTH); Beete Rd, W of Norseman-Salmon Gums Rd, 19 Feb. 2000, *M.E. French 1148* (PERTH); along (R) side of Eyre Hwy, c. 3 mls S of Daniell Siding, 16 Nov. 1970, *J.P. Baker 79* (CANB, NSW); S of Norseman on Norseman-Esperance Hwy, 10 Dec. 2019, *M.E. French 3274* (PERTH).

4. *Eucalyptus perangusta* Brooker

Nuytsia 6(3): 330–332, Figs 1, 2c, 3c (1988). — **Holotype:** Oldfield's road [Oldfield Rd], E of Young River crossing, 9 Apr. 1983, *M.I.H. Brooker 8076 & S.D. Hopper* (PERTH1393421). **Isotypes:** AD; CANB417789; MEL1609837; NSW350614.

Mallee to 5 m tall; lignotuber present, lignotuber resprouter (Nicolle 2006). *Bark* smooth throughout, decorticating annually in strips, grey over cream to pale tan. *Branchlets* non-pruinose. *Seedling leaves* opposite for 12–20+ pairs, nodes 2–8 mm apart, sessile, linear to narrowly elliptical, 16–65 mm long × 1–5 mm wide, length:width ratio typically 8–20:1, slightly discolorous, dull, green, non-pruinose. *Coppice leaves* similar but typically larger and more spaced, becoming disjunct. *Mature crown* composed entirely of adult leaves. *Adult leaves* held erect, with petioles 1–5 mm long, lamina linear, 40–105 mm long × 1–3 (–5) mm wide, length:width ratio typically 17–44:1, glossy, green, non-pruinose; tertiary venation obscure; oil glands numerous, connected to vein network (intersectional oil glands). *Inflorescences* 7–9-flowered; peduncles angular to slightly flattened, 1.5–4 mm long; pedicels 1–2 mm long. *Flower buds* ovoid, 5.5–9 mm long × 2–3 mm diam.; opercula bluntly conical to slightly beaked, 3–4 mm long, length:width ratio typically 1–1.4:1. *Fruits* truncate-globose to cupular to obconic, 3.5–5 mm long × 3.5–5.5 mm diam.; disc near-level to descending; valves 3 (4), at or below rim level. **Fig. 10.**

Diagnostic characters. Distinguished within *E.* ser. *Porantherae* by the following combination of characters: Lignotuberous mallee. Bark smooth and shedding throughout. Branchlets non-pruinose. Seedling leaves opposite, moderately-spaced, linear to narrowly elliptical (length:width ratio 8–20:1), green, non-pruinose (Fig. 11). Adult leaves linear (length:width ratio 17–44:1), glossy and green at all ages. Pedicels short. Opercula bluntly conical to slightly beaked. Fruit truncate-globose to cupular to obconic.

Illustrations. M.I.H. Brooker & D.A. Kleinig, *Field Guide Eucalypts* 2: 308 (1990); 2nd edn, 2: 308 (2001); 3rd edn, 2: 282 (2016); A.V. Slee *et al.*, *EUCLID Eucalypts of Australia* CD ROM, *Eucalyptus perangusta* (2006); M.E. French, *Eucalypts W. Austral. Wheatbelt* 248, 249 (2012); M.E. French & D. Nicolle, *Eucalypts W. Austral. - S.W. Coast & Ranges* 208, 209 (2019).

Distribution and habitat. Endemic to W.A., where it is distributed from the Truslove area (north of Esperance) westwards towards Lake King and to near Bandalup Hill, westwards of which it grades into *E. olivina* (Fig. 12). It grows on level topography on pale grey to pale yellow sand or gravelly sand, in mallee shrubland vegetation. Associated eucalypts include *Eucalyptus deflexa*, *E. flocktoniae* subsp. *flocktoniae*, *E. forrestiana*, *E. misella*, *E. oleosa* subsp. *cylindroidea*, *E. phaenophylla*, *E. pileata*, *E. pleurocarpa*, *E. quadrans*, *E.* sp. Southern wheatbelt, *E. subtilis*, *E. suggrandis* subsp. *suggrandis*, *E. tenera*, *E. tumida*, *E. valens* and *E. varia*.

Conservation status. Globally listed as 'Near Threatened' on the IUCN Red List of Threatened Species (IUCN 2020). We concur with this assessment.

Not a listed taxon under Conservation Codes for Western Australian Flora (Smith & Jones 2018). The species is poorly represented in conservation reserves.

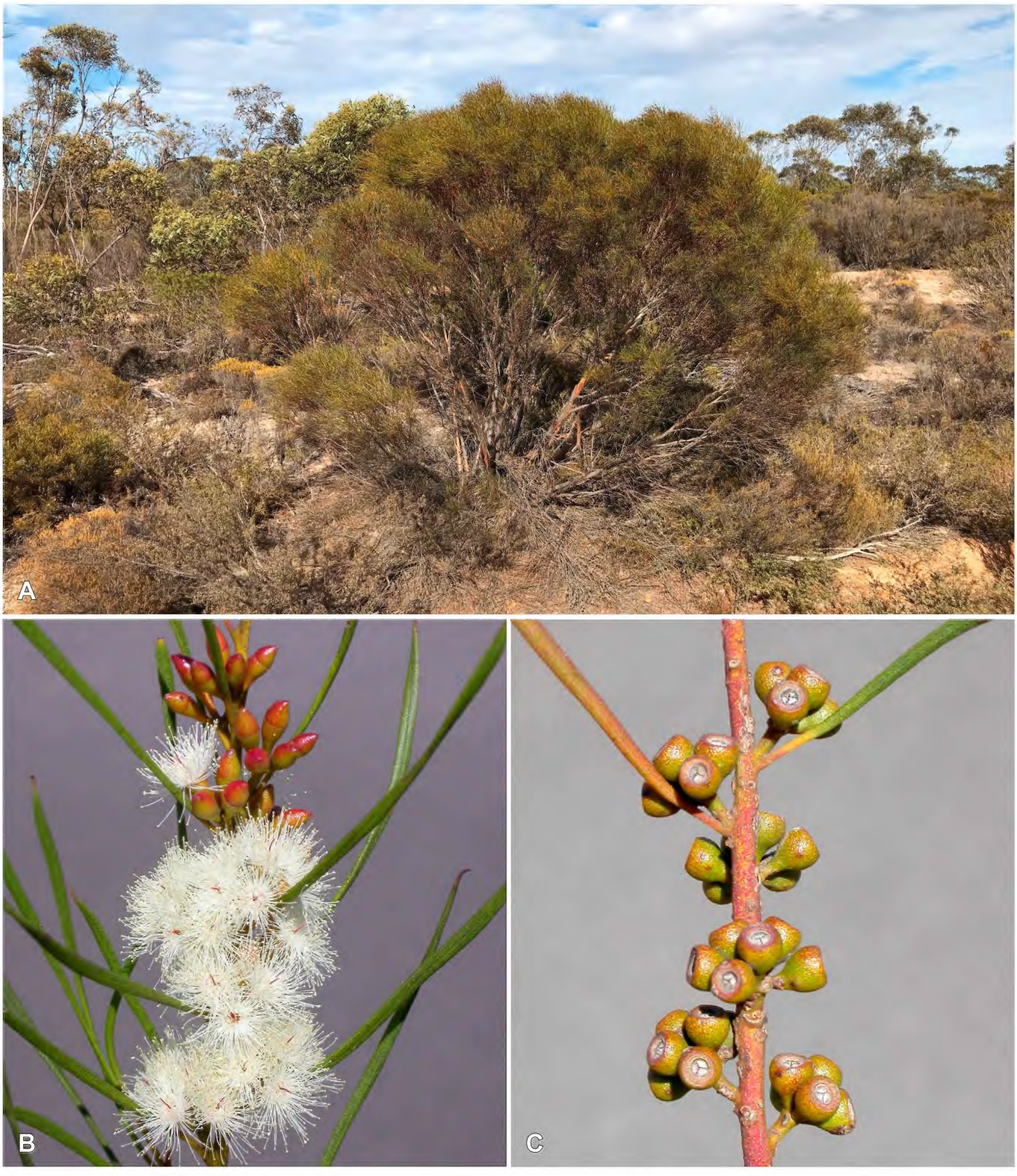

Fig. 10. *Eucalyptus perangusta*. **A** habit and habitat (*D. Nicolle 148*, Field Rd, W.A.); **B** leaves, buds and flowers (F1 of *D. Nicolle 3712 & M.E. French*, Cascades to Lake King road, W.A.); **C** fruits (F1 of *D. Nicolle 3712 & M.E. French*, Cascades to Lake King road, W.A.).

Common names. Fine-leaved Mallee (Slee *et al.* 2006; French 2012; Brooker & Kleinig 2016; French & Nicolle 2019), Ravensthorpe Mallee (Brooker & Kleinig 2016).

Notes. A distinctive species in the field due to its completely smooth and shedding bark, its crown of linear adult leaves on short petioles, its short peduncles and pedicels, its ovoid buds with conical to bluntly conical opercula, and its fruits which have a wrinkled surface upon drying.

The closely-related *E. austrina* L.A.S.Johnson & K.D. Hill ex D.Nicolle & M.E.French and *E. lunata* can also have linear adult leaves (although not as narrow as *E. perangusta*), and many specimens of these species were previously included in *E. perangusta*. *Eucalyptus austrina* and *E. lunata* are easily distinguished from

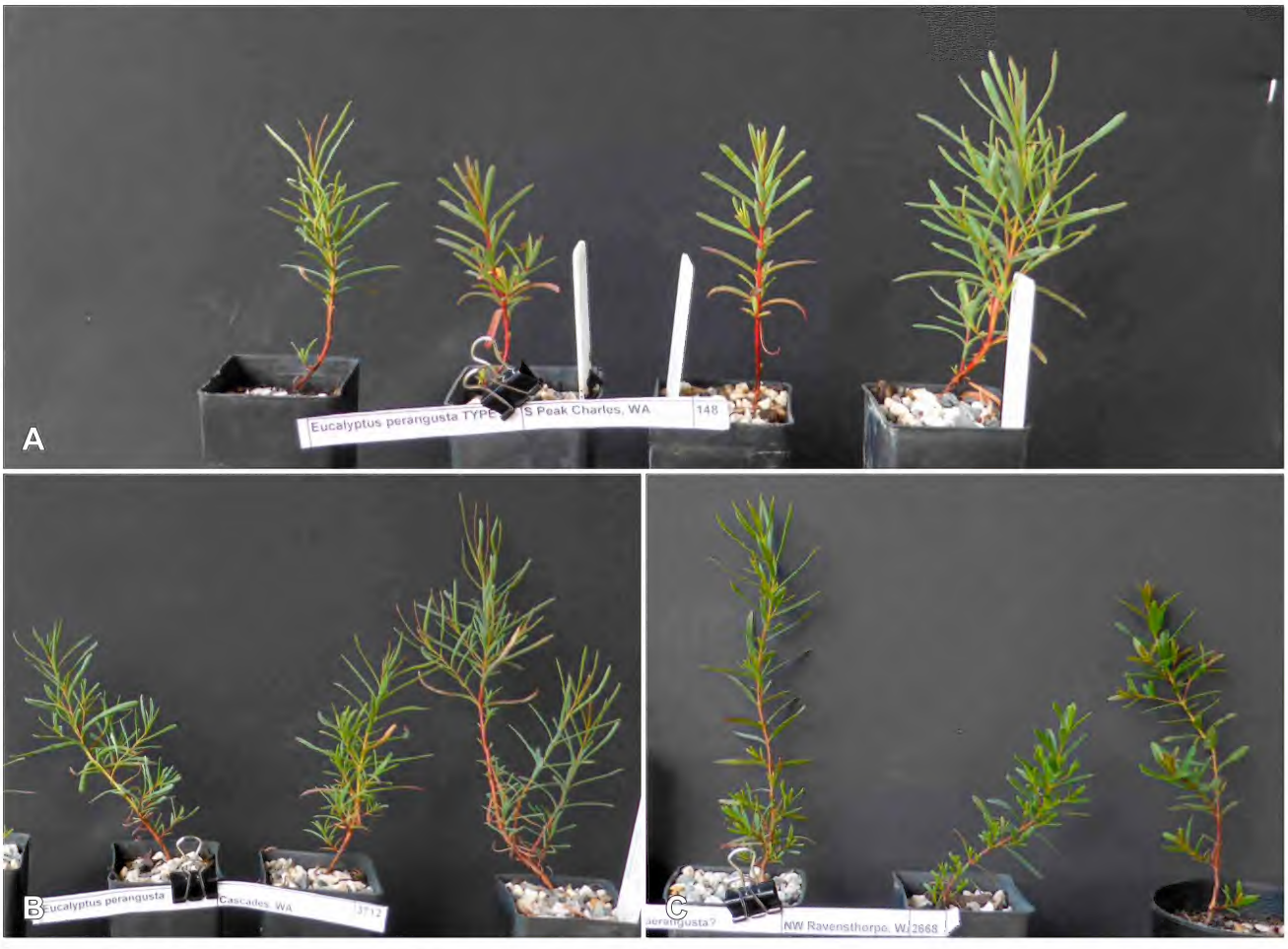

Fig. 11. *Eucalyptus perangusta* seedlings. **A** F1 of *D. Nicolle 148*, Field Rd between Rollond Rd and Lort River, W.A.; **B** F1 of *D. Nicolle 3712 & M.E. French*, Cascades to Lake King road, W.A.; **C** F1 of *M.E. French 2668*, NE of Ravensthorpe on Nindibillup Rd, W.A.

E. perangusta in their juvenile phase, having ovate to near-orbicular, greyish seedling leaves. *Eucalyptus perangusta* has not been recorded west of the Newdegate-Ravensthorpe Road.

The closely related *E. olivina* can be distinguished from *E. perangusta* by its crowded seedling leaves, its beaked opercula and its non-wrinkled fruits upon drying. Intergrades between the two species occur at the western end of the distribution of *E. perangusta*, between Lake King and the Ravensthorpe Range.

Selected specimens

WESTERN AUSTRALIA (west to east). Hatter Hill Rd, 7 Jan. 2007, *D. Nicolle 5052 & M.E. French* (PERTH); NE of Ravensthorpe on Nindibillup Rd, 20 Mar. 2014, *M.E. French 2668* (AD, PERTH); Mason Bay Rd proposed N realignment, c. 7 km NNW of Bandalup Hill, 14 May 1999, *G.F. Craig 4036* (PERTH); S of Lake Tay on Lake Tay rd ex new Cascade rd, NW of Cascade, 26 Feb. 2001, *M.E. French 1275* (PERTH); Cascades to Lake King rd, between Cascades and Lake Tay rd turnoff, 20 Jan. 2001, *D. Nicolle 3712 & M.E. French* (CANB, PERTH); Lake Tay to Peak Charles tk, N of Cascade, 8 Sep. 2020, *M.E. French 3397* (PERTH); c. 23 km from Rockhole Rd on Rawlinsons Rd, 9 Apr. 1983, *M.I.H. Brooker 8077* (CANB, PERTH); Rollonds Rd near Edwards Rd (NW of Cascades), 14 Oct. 1996, *W. O'Sullivan 166* (PERTH); Field Rd between Rollond Rd and Lort River, 6 Dec. 1992, *D. Nicolle 148* (AD); c. 13 km N of Rollond Rd on Field Rd, 7 Sep. 1984, *M.I.H. Brooker 8672* (AD, CANB, PERTH); Lort River crossing on Grass Patch Rd, 4 km W of Lort River bin, 9 Sep. 1999, *A.V. Slee 4226* (CANB); The Cups, N of Rollond Rd, 19 Jan. 2021, *D. Nicolle 8013 & M.E. French* (PERTH); S of Truslove on Hwy One, 22 Jan. 1996, *D. Nicolle 1643* (AD, CANB, PERTH).

5. *Eucalyptus olivina* Brooker & Hopper

Nuytsia 9(1): 45–46 (1993). — **Holotype:** At turn-off to Lake Cronin between Cross Roads and Mt Holland, E of Hyden, 22 July 1988, *M.I.H. Brooker 10011 & C.J. Ranford* (PERTH01392972). **Isotypes:** AD99126378; CANB388216; MEL115792; NSW.

Mallee to 10 m tall; lignotuber present, lignotuber resprouter (Nicolle 2006). *Bark* smooth throughout, decorticating annually in strips, grey to pinkish over tan-yellow to pale grey to white. Large individuals sometimes with loose, flaky, rough bark for up to 1 m. *Branchlets* non-pruinose. *Seedling leaves* opposite for a few nodes then becoming disjunct, nodes 1–10 (–14) mm apart, ± sessile, linear to narrowly elliptic or narrowly spathulate, 13–38 mm long × 1.5–7 mm wide, length:width ratio typically 4–8:1, ± concolorous,

dull, green to grey-green, slightly or variably pruinose. *Coppice leaves* similar but typically larger and more spaced. *Mature crown* composed entirely of adult leaves. *Adult leaves* with petioles 3–10 mm long, lamina linear to narrow-lanceolate, 40–85 mm long × 3–9 mm wide, length:width ratio typically 7–15:1, ± glossy, green to slightly blue-green or olive green, non-pruinose; tertiary venation dense; oil glands scattered, connected to vein network (intersectional oil glands). *Inflorescences* 7–11-flowered; peduncles terete to very slightly flattened, 3–10 mm long; pedicels 1–3 mm long. *Flower buds* fusiform, 6–10 mm long × 2.5–3 mm diam.; opercula beaked, 6–7 mm long, length:width ratio typically 1.5–2:1. *Fruits* cupular to truncate-globose, 3.5–5 mm long × 3–5 mm diam.; disc descending; valves 3 (4), at or below rim level. **Fig. 13.**

Diagnostic characters. Distinguished within *E.* ser. *Porantherae* by the following combination of characters: Lignotuberous mallee. Bark smooth and shedding throughout. Branchlets non-pruinose. Seedling leaves disjunct, crowded, linear to narrowly elliptic or narrowly spathulate (length:width ratio 4–8:1), green to grey-green, variably pruinose (Fig. 14), adult leaves linear to narrow-lanceolate (length:width ratio 7–15:1), ± glossy, green to slightly blue-green. Opercula beaked. Fruits cupular to truncate-globose.

Illustrations. M.I.H. Brooker & D.A. Kleinig, *Field Guide Eucalypts* 3rd edn, 2: 281 (2016); M.E. French, *Eucalypts W. Austral. Wheatbelt* 250, 251 (2012).

Distribution and habitat. Endemic to W.A., where it is widely distributed from south-east of Harrismith eastwards to the Kumarl area (between Norseman and Esperance), north as far as the Holleton area, and south almost to Ravensthorpe (Fig. 12). It typically grows on plains, slight rises and shallow depressions, in white to yellowish sand, gravelly sand or sandy loam or sometimes in reddish clay-loam, overlying laterite or limestone, as a component of mallee shrubland, mixed mallee woodland or as an emergent in low shrubland vegetation. Associated eucalypts include *Eucalyptus albida*, *E. deflexa*, *E. flocktoniae* subsp. *flocktoniae*, *E. longicornis*, *E. neutra*, *E. phaenophylla*, *E. phenax* subsp. *phenax*, *E. pileata*, *E. platycorys*, *E. rigidula* subsp. *rigidula*, *E. salmonophloia*, *E. sheathiana*, *E. sporadica*, *E. spreta* and *E. tenera*.

Conservation status. Globally listed as 'Near Threatened' on the IUCN Red List of Threatened Species (IUCN 2020). We concur with this assessment.

Not a listed taxon under Conservation Codes for Western Australian Flora (Smith & Jones 2018). Recorded from Frank Hann National Park and Dragon Rocks and Lake Cronin nature reserves.

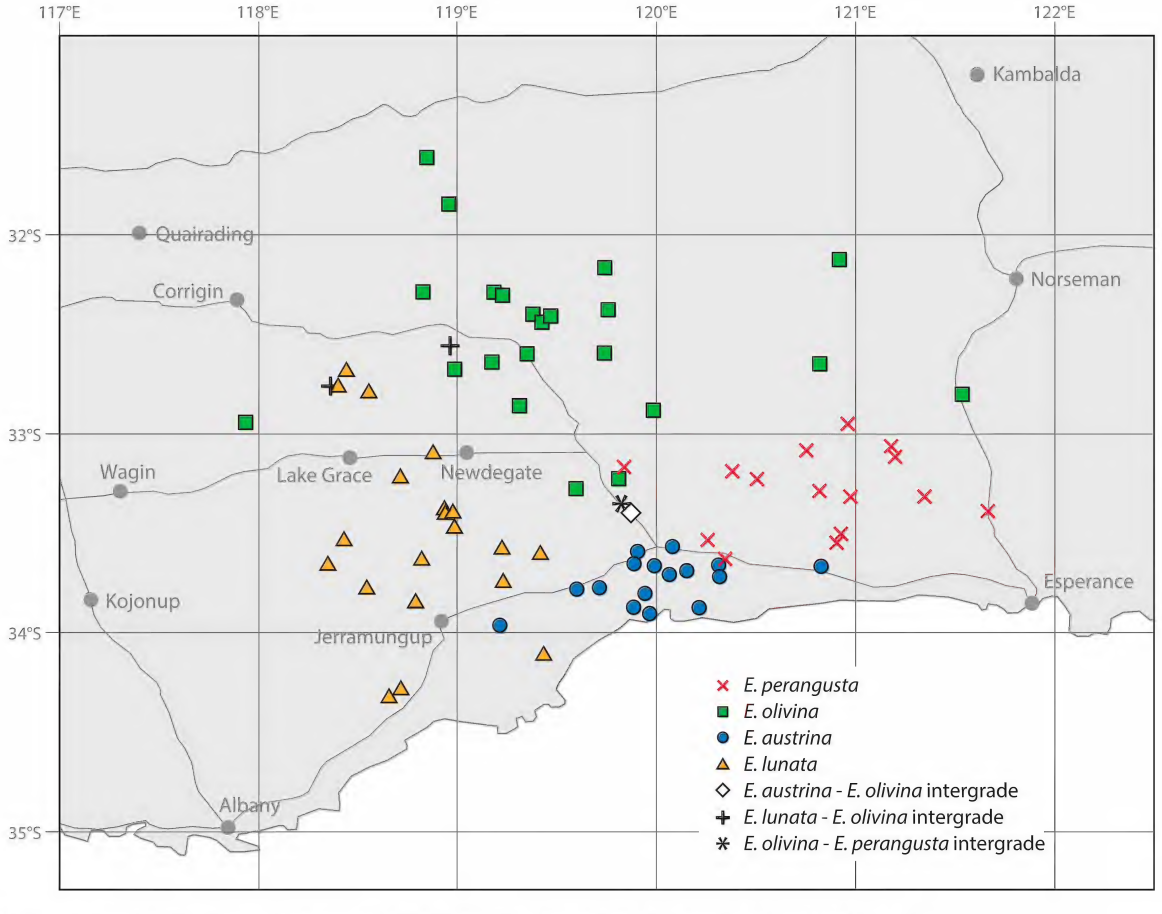

Fig. 12. Distribution of *Eucalyptus perangusta*, *E. olivina*, *E. austrina* and *E. lunata* in Western Australia.

Common names. Olive-leaved Mallee (French 2012; Brooker & Kleinig 2016).

Notes. The seedling leaves of *E. olivina* are small, narrow, crowded, and disjunct. Their phyllotaxis is not easily discernible, possibly being spirally arranged. Such crowded and disjunct seedlings leaves are otherwise only seen in *E.* ser. *Porantherae* in the arid-zone species *E. formanii* and *E. plumula*.

Eucalyptus olivina grades into *E. latens* at the western end of its distribution in the Corrigin to Harrismith area, with *E. lunata* in the Kulin to Hyden area (at the northern edge of the distribution of *E. lunata*), with *E. perangusta* in the Lake King to Ravensthorpe Range area (at the western edge of the distribution of *E. perangusta*), and with *E. austrina* north-west of Ravensthorpe (at the northern edge of the distribution of *E. austrina*). In all these cases, these intergrading populations are near-impossible to identify using adult morphology, but are easily discernible by their seedling morphology, as *E. olivina* has quite different seedlings compared to these other species, and intergrading populations have leaves that are intermediate in size and shape between *E. olivina* and the other species.

Fig. 13. *Eucalyptus olivina*. **A** habitat and habit (*D. Nicolle 5048 & M.E. French*, Mt Gibbs track, W.A.); **B** coppice foliage from damaged lignotuber (*D. Nicolle 5049 & M.E. French*, Mt Gibbs track, W.A.).

Eucalyptus olivina is associated with *E. albida* and *E. rigidula* subsp. *rigidula* at some sites, although hybrids have not been recorded. The distribution of *Eucalyptus olivina* overlaps with that of *E. ecdysiastes*, but the two species are not known to grow together.

Selected specimens

WESTERN AUSTRALIA (west to east). SE Harrismith, near corner of Fence Rd and Muller Rd, 11 Dec. 2014, *M.E. French 2761* (PERTH); Billericay Rd East, E of Hyden-Mount Walker Rd, N of Hyden, 17 July 2014, *M.E. French 2690* (PERTH); Bodallin South Rd, 24 Nov. 2013, *D. Nicolle 6686 & M.E. French* (AD, PERTH); Di Russo Rd, SE of Hyden, 16 Apr. 2015, *M.E. French 2783* (PERTH); Murray Rock Rd, NE of Hyden, 23 Aug. 2014, *M.E. French 2710* (PERTH); on private property N of Murray Rock Rd, NE of Hyden, E of King Rocks, 23 Aug. 2014, *M.E. French 2708* (PERTH); Mount Vernon Rd, NE of Newdegate, 30 July 2001, *M.E. French 2700* (PERTH); Hyden-Norseman

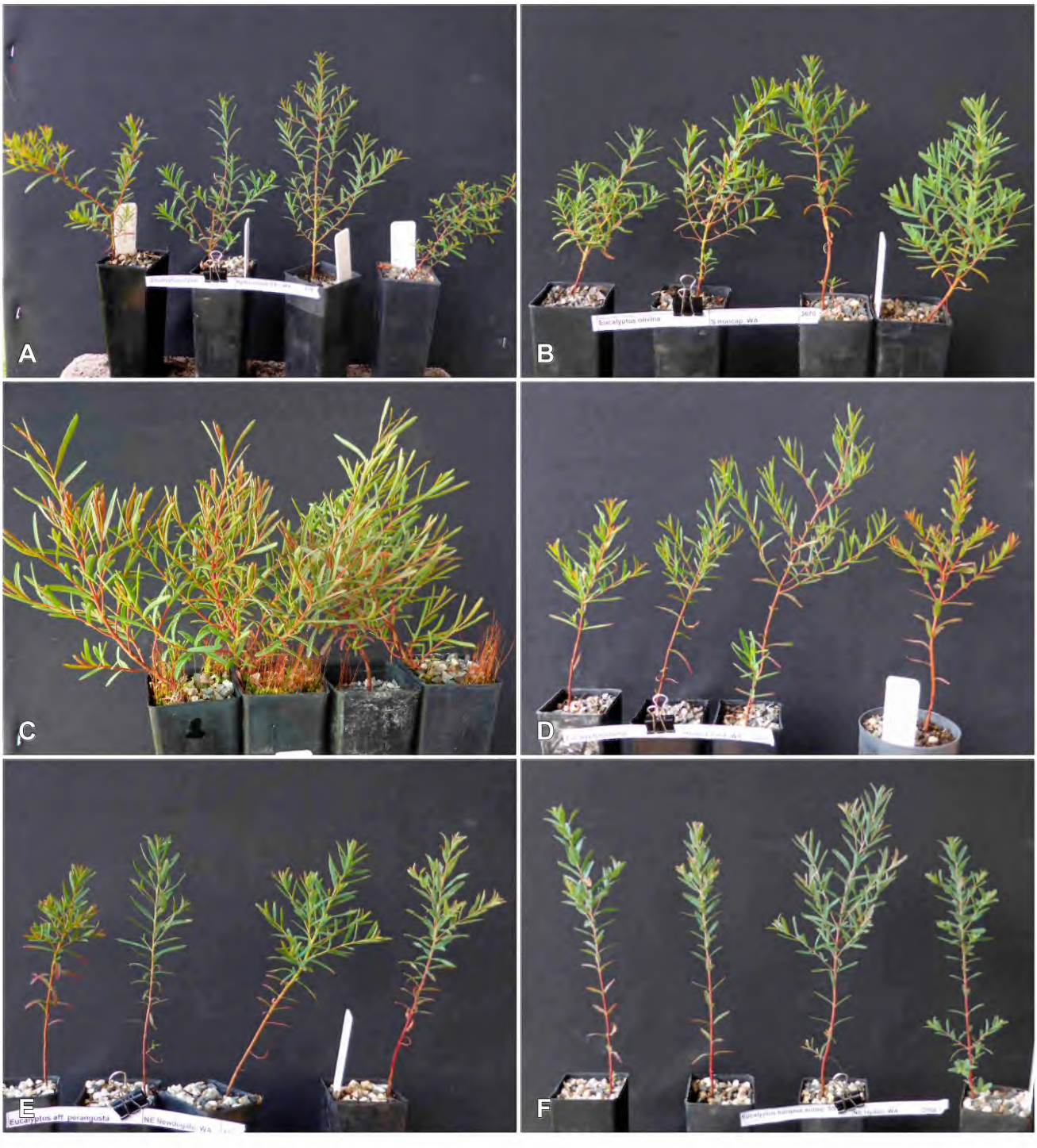

Fig. 14. *Eucalyptus olivina* seedlings. **A** F1 of *D. Nicolle 319*, corner Marvel Loch-Forrestania Rd and Lake Cronin track, W.A.; **B** F1 of *D. Nicolle 3670 & M.E. French*, S of Lake Cronin crossroads towards South Ironcap, W.A.; **C** F1 of *D. Nicolle 6383 & M.E. French*, Kumarl Rd, just E of Coolgardie-Esperance Hwy, W.A.; **D** F1 of *M.E. French 2696*, at base of Emu Rock, E of Hyden, W.A.; **E** F1 of *M.E. French 2700*, Mount Vernon Rd, NE of Newdegate, W.A.; **F** F1 of *M.E. French 2708*, NE of Hyden, E of King Rocks, W.A.

Rd, E of Hyden, 25 Sep. 2014, *M.E. French 2727* (PERTH); c. 45 km from Hyden towards Varley, 1 May 1999, *A.V. Slee 4100* (CANB, PERTH); Uart Rock, private property off Bushfire Rock Rd, SE of Hyden, 20 July 2014, *M.E. French 2695* (PERTH); Holland Tk, Emu Rock, E of Hyden, 29 July 2014, *M.E. French 2696* (PERTH); Old Newdegate Rd, SW of Lake King, 11 Nov. 2015, *M.E. French 2830* (PERTH); S of Mt Holland on Forrestania-Southern Cross Rd, 11 Dec. 2014, *M.E. French 2759* (PERTH); c. 22 km S of Lake Cronin crossroads towards South Ironcap, 11 Nov. 2000, *D. Nicolle 3670 & M.E. French* (CANB, PERTH); corner Southern Cross-Forrestania Rd and Lake Cronin tk, 13 Dec. 1992, *D. Nicolle 319* (AD); Forrestania Southern Cross Rd, W of Lake Cronin, 25 Sep. 2014, *M.E. French 2728* (PERTH); c. 3 km N of Muncaster Rd on Hatter Hill Rd, SE of Lake King, 12 Nov. 2015, *M.E. French 2832* (PERTH); Disappointment Rock, just off the new Hyden to Norseman Rd, 10 Nov. 2000, *D. Nicolle 3662 & M.E. French* (CANB, PERTH); Mt Gibbs tk, 7 Jan. 2007, *D. Nicolle 5048 & M.E. French* (AD, CANB, PERTH); Southern end of Bremer Range tk, 20 Mar. 2010, *D. Nicolle 5475 & M.E. French* (CANB, PERTH); Kumarl Rd, just E of Coolgardie-Esperance Hwy, 5 May 2012, *D. Nicolle 6383 & M.E. French* (AD, PERTH).

6. *Eucalyptus austrina* L.A.S.Johnson & K.D.Hill ex D.Nicolle & M.E.French, *sp. nov.*

Holotypus: Western Australia, Road Eleven, east of Yarracarrup Creek, 17 Oct. 2019, *D. Nicolle 7743* (PERTH9248161). **Isotypus:** AD.

Eucalyptus sp. Ravensthorpe (*A.S. George 616*): D.Nicolle *et al.*, *Nuytsia* 22(3): 99 (2012).

This species has previously been recognised under the designation *Eucalyptus* 'austrina' (W.A. Herbarium 2019) but the name was never formally published.

Mallee to 6 m tall; lignotuber present, lignotuber resprouter (Nicolle 2006). *Bark* smooth throughout, decorticating annually in strips, grey to pale grey over tan to cream. *Branchlets* non-pruinose. *Seedling leaves* opposite for 12–25+ pairs, nodes 5–30 mm apart, sessile, ovate to elliptic, 10–22 mm long × 3–16 mm wide, length:width ratio typically 1.2–3:1, slightly discolorous, dull, grey-green, new growth pruinose. *Coppice leaves* similar but typically larger, more spaced and becoming disjunct. *Mature crown* composed entirely of adult leaves. *Adult leaves* with petioles 4–12 mm long, lamina narrow-lanceolate, 40–80 mm long × 4–10 mm wide, length:width ratio typically 7–13:1, glossy, green, non-pruinose; tertiary venation dense; oil glands numerous, connected to vein network (intersectional oil glands). *Inflorescences* 7–13-flowered; peduncles angular to very slightly flattened, 4–9 mm long; pedicels 1–4 mm long. *Flower buds* fusiform, 6–9 mm long × 2.5–4 mm diam.; opercula conical to slightly beaked, 3–6 mm long, length:width ratio typically 1.2–2:1. *Fruits* barrel-shaped to cupular, 4–6 mm long × 3–5 mm diam.; disc level to descending; valves 3 or 4, around rim level or below. **Fig. 15.**

Diagnostic characters. Distinguished within *E.* ser. *Porantherae* by the following combination of characters: Lignotuberous mallee. Bark smooth and shedding throughout. Branchlets non-pruinose. Seedling leaves opposite, moderately-spaced, ovate to elliptic (length: width ratio 1.2–3:1), grey-green, new growth pruinose (Fig. 16). Adult leaves narrow-lanceolate (length:width ratio 7–13:1), glossy, green. Pedicels distinct. Opercula conical to slightly beaked. Fruit barrel-shaped to cupular.

Illustrations. M.E. French & D. Nicolle, *Eucalypts W. Australia - S.W. Coast & Ranges* 212, 213 (2019).

Distribution and habitat. Endemic to W.A., where it is restricted to near the south coast, from the Ravensthorpe Range south-westwards to the Fitzgerald River area and eastwards to the Oldfield, Munglinup and Young rivers in the Munglinup area (Fig. 12). It commonly grows in creek gullies, but also occurs on higher ground in undulating areas, on white to pale brown loams to gravelly granitic sand, in mallee shrubland. Associated eucalypts include *Eucalyptus conglobata* subsp. *perata*, *E. flocktoniae* subsp. *flocktoniae*, *E. improcera*, *E. leptocalyx*, *E. occidentalis*, *E. phaenophylla*, *E. pleurocarpa*, *E. proxima*, *E. sporadica*, *E. suggrandis* subsp. *suggrandis* and *E. uncinata* subsp. *uncinata*.

Conservation status. Not yet assessed under the IUCN Red List of Threatened Species (IUCN 2020). Considering its known distribution, life cycle, and threats, we believe that an IUCN Red List category of 'Near Threatened' is appropriate for the species.

Not a listed taxon under Conservation Codes for Western Australian Flora (Smith & Jones 2018). Many populations occur in Fitzgerald River National Park.

Etymology. From the Latin *austrina* meaning 'southern, of the south wind' referring to its distribution near the south coast in Western Australia.

Common names. Southern Red Mallee (French & Nicolle 2019).

Notes. The adult and seedling morphology of *E. austrina* suggests that it is most closely related to *E. latens* (which occurs much further west) and *E. lunata* (which occurs to the immediate north-west of *E. austrina*). It can be distinguished from both of these species by its seedling leaves. Several other *E.* ser. *Porantherae* species occur within the distribution of *E. austrina*, namely *E. albida*, *E. dissimulata*, *E. lunata* and *E. uncinata*, but hybrids with these species have not been recorded. Intergrades between *E. austrina* and *E. olivina* have been recorded at the inland extent of *E. austrina*, north-west of Ravensthorpe, and can be distinguished by their intermediate seedling morphology.

Selected specimens

WESTERN AUSTRALIA (west to east). Lower slope of Twertup Creek valley, FRNP, SE of Jerramungup, 28 Oct.

2018, *M.E. French 3064* (PERTH); northern fireline, c. 3 km NE of Fitzgerald tk, 25 Nov. 1991, *M.I.H. Brooker 10922* (AD, CANB, NSW, PERTH); Hamersley River, W bank on Old Ongerup Rd, Fitzgerald River N.P., SW of Ravensthorpe, 13 Nov. 2015, *M.E. French 2838* (PERTH); Hamersley Drive, SW of Ravensthorpe, Fitzgerald River N.P., 23 Mar. 2015, *M.E. French 2780* (PERTH); Quoin Head Tk, Fitzgerald River N.P., NW of Hopetoun, 28 Oct. 2018, *M.E. French 3067* (PERTH); Quoin Head Tk, Fitzgerald River N.P., NW of Hopetoun, 10 Feb. 2018, *M.E. French 2965* (PERTH); c. 9 km on Old Ongerup Rd [Cocanarup Rd] ex highway, W [SW] from Ravensthorpe-Jerramungup Rd, 13 Nov. 2015, *M.E. French 2836* (PERTH); Cocanarup South Tk, SW of Ravensthorpe, 1 Mar. 2018, *M.E. French 2982* (PERTH); Jerramungup Rd on road to Lake King, 7 June 1983, *M.I.H. Brooker 8174* (CANB, PERTH); Moir Tk N of Hamersley Drive, NW of Hopetoun, 28 Oct. 2018, *M.E. French 3069* (PERTH); Hamersley Drive, W of Hopetoun and East Mount Barren, Fitzgerald River N.P., 23 Mar. 2015, *M.E. French 2782* (PERTH); Fitzgerald River N.P.; Hamersley Drive W of turnoff to East Mylia Beach, 18 Sep. 1999, *A.V. Slee 4262* (CANB, PERTH); Tk W off Moir Rd, SW of Ravensthorpe, 13 Mar. 2018, *M.E. French 2998* (PERTH); Road Eleven, SW of Ravensthorpe,

Fig. 15. *Eucalyptus austrina*. **A** habit and habitat; **B** coppice growth from lignotuber (both *D. Nicolle 7743*, E of Yarracarrup Creek, W.A.).

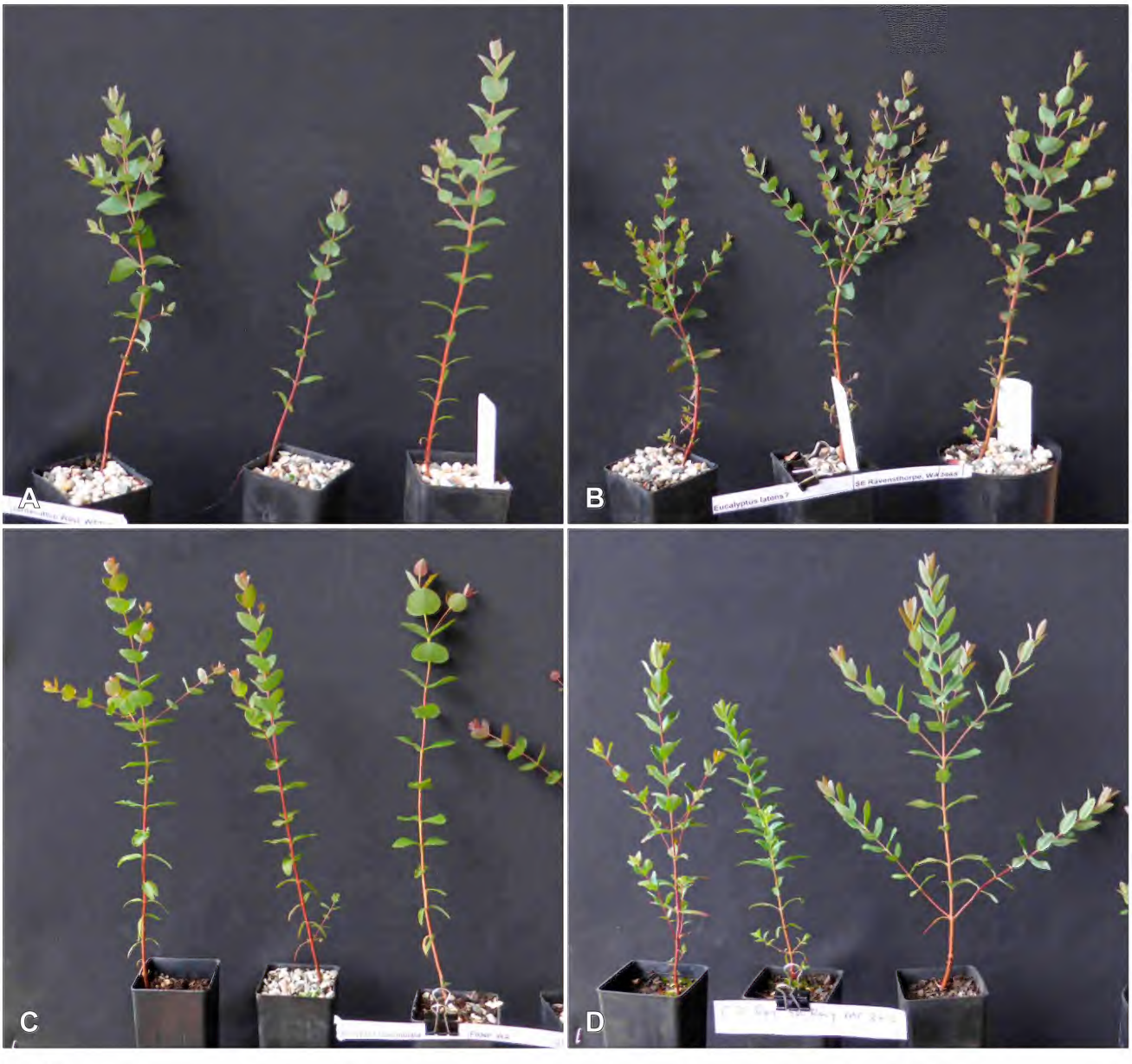

Fig. 16. *Eucalyptus austrina* seedlings. **A** F1 of *M.E. French 2653*, Jerdacuttup River, Jerdacuttup North Rd, NE of Hopetoun, W.A.; **B** F1 of *M.E. French 2665*, Hatfield Rd, SE of Ravensthorpe, W.A.; **C** F1 of *M.E. French 2782*, Hamersley Drive, Fitzgerald River N.P., W.A.; **D** F1 of *M.E. French 2836* (PERTH 08170878), Cocanarup Rd, W of Ravensthorpe, W.A.

1 Mar. 2018, *M.E. French 2984* (PERTH); c. 6 to 7 km E of Ravensthorpe, 15 Oct. 2018, *M.E. French 3048* (PERTH); c. 3 km on rd 11, W of Kundip, S of Ravensthorpe, 12 Nov. 2015, *M.E. French 2835* (PERTH); c. 4 km E on Springvale Rd ex Hopetoun-Ravensthorpe Rd, 12 Nov. 2015, *M.E. French 2833* (PERTH); Jerdacuttup River, Jerdacuttup North Rd, NE of Hopetoun, 21 Feb. 2014, *M.E. French 2653* (PERTH); Hatfield Tk, SE of Ravensthorpe, 20 Mar. 2014, *M.E. French 2665* (PERTH); Reynolds Tk, N of Munglinup, 15 Oct. 2018, *M.E. French 3059* (PERTH).

7. *Eucalyptus lunata* D.Nicolle & M.E.French, *sp. nov.*

Holotypus: Western Australia, Mallee Rd, N of Reserve Rd, 23 Mar. 2010, *D. Nicolle 5503 & M.E. French* (PERTH08301190). **Isotypi:** AD; CANB; NSW.

Eucalyptus sp. Sullivan Soak (*D. Nicolle & M. French DN 5503*): D.Nicolle *et al.*, *Nuytsia* 22(3): 108 (2012).

Mallee to 5 m tall; lignotuber present, lignotuber resprouter (Nicolle 2006). *Bark* smooth throughout, decorticating annually in strips, grey to pale grey over pale orange-tan to cream. *Branchlets* non-pruinose. *Seedling leaves* opposite for numerous nodes, nodes 2–5 mm apart (sometimes so closely-spaced that they are of indeterminate arrangement rather than opposite), sessile, ovate to near-orbicular or cordate, 7–18 mm long × 4–15 mm wide, length:width ratio typically 1.1–2:1, slightly discolorous, dull, grey-green to grey, pruinose. *Coppice leaves* similar but typically larger, more spaced and becoming disjunct. *Mature crown* composed entirely of adult leaves. *Adult leaves* with petioles 2.5–7 mm long, lamina linear to narrow-lanceolate, 30–70 mm long × 1.5–5 (–7) mm wide, length:width ratio typically 10–23:1, glossy, green, non-pruinose; tertiary venation dense; oil glands numerous, connected to vein network (intersectional oil glands). *Inflorescences*

7–11-flowered; peduncles terete to angular, 2–9 mm long; pedicels 1.5–3.5 mm long. *Flower buds* ovoid to fusiform, 4.5–9 mm long × 2–3.5 mm diam.; opercula bluntly conical to very slightly beaked, 2.5–5 mm long, length:width ratio typically 1–2:1. *Fruits* cupular to truncate globose or shortly-barrel-shaped, 2.5–5 mm long × 2.5–5 mm diam.; disc descending; valves 3 or 4, at rim level or below. **Fig. 17.**

Diagnostic characters. Distinguished within *E.* ser. *Porantherae* by the following combination of characters: Lignotuberous mallee. Bark smooth and shedding throughout. Branchlets non-pruinose. Seedling leaves opposite or indeterminate, densely-spaced, ovate to near-orbicular or cordate (length:width ratio 1.1–2:1), greyish, pruinose (Fig. 18). Adult leaves linear to narrow-lanceolate (length:width ratio 10–23:1), glossy and green at all ages. Pedicels distinct. Opercula bluntly conical to very slightly beaked. Fruits cupular to truncate globose or shortly-barrel-shaped.

Illustrations. M.E. French, *Eucalypts W. Austral. Wheatbelt* 257 (2012), both seedling paintings; D. Nicolle, *Smaller Eucalypts for Planting in Australia* 117 (2016).

Fig. 17. *Eucalyptus lunata*. **A** habitat and habit (*D. Nicolle 5503 & M.E. French*, Mallee Rd, N of Reserve Rd, W.A.); **B** coppice foliage from damaged lignotuber (at *D. Nicolle 5504 & M.E. French*, Mallee Rd, N of Reserve Rd, W.A.).

Distribution and habitat. Endemic to W.A., where it is distributed from the Jilakin area (east of Kulin) southwards to the Boxwood Hill area (Fig. 12). It grows on sites low in the landscape, such as near salt lakes, in broad shallow depressions, and in broad valleys, typically in white sand overlying clay. It is a component of mallee shrubland or mixed mallee woodland. Associated eucalypts include *Eucalyptus captiosa*, *E. dissimulata*, *E. flocktoniae* subsp. *flocktoniae*, *E. incrassata s.lat.*, *E. neutra*, *E. occidentalis*, *E. phaenophylla*, *E. phenax* subsp. *phenax*, *E. salmonophloia*, *E.* sp. Southern wheatbelt, *E. sporadica*, *E. suggrandis* subsp. *promiscua* and *E. uncinata* subsp. *uncinata*.

Conservation status. Not yet assessed under the IUCN Red List of Threatened Species (IUCN 2020). Considering its known distribution, life cycle, and threats, we believe that an IUCN Red List category of 'Near Threatened' is appropriate for the species.

Not a listed taxon under Conservation Codes for Western Australian Flora (Smith & Jones 2018).

Fig. 18. *Eucalyptus lunata* seedlings. **A** F1 of *D. Nicolle 3436 & M.E. French*, W of Pingaring on Cargannocking-Pingaring Rd, W.A.; **B** F1 of *D. Nicolle 3742 & M.E. French*, Rabbit Proof Fence Rd, W.A.; **C** F1 of *D. Nicolle 5503 & M.E. French*, Mallee Rd, N of Reserve Rd, W.A.; **D** F1 of *M.E. French 2669*, Dornock Rd, SW of Pingaring, W.A.; **E** F1 of *M.E. French 2671*, Dandagin Rd, NW of Pingaring, W.A.

Recorded from Fitzgerald River National Park and from Lake Bryde and Lake Magenta nature reserves.

Etymology. The epithet is from the Latin *lunatus* (bent into a crescent), alluding to its commonly known trade name of *E.* 'Moon Lagoon'. The name 'Moon Lagoon' was first coined by Peter Luscombe in the early 1990s, when he owned and managed the Australian native seed service *Nindethana*. Luscombe, recognising the potential of the species for cut foliage, collected commercial quantities of seed of the species from his property called 'Moon Lagoon', adjacent to Lake Chinocup Reserve just west of Pingrup. The property was partly named for its crescent-shaped saltpans and small salt lakes, but especially for a defining event in Luscombe's life: "camping with my two young daughters and walking across one of the salt crystal lakes with about 1 cm of water in it, with moon and stars above and below, gave the impression of walking in space – they've never forgotten after 30 years" (Peter Luscombe, pers. comm.).

Common names. Moon Lagoon Mallee (Nicolle 2016).

Notes. A distinctive species, especially when seedling or coppice growth is present. Specimens have historically been included in *E. perangusta*, which has very different seedling morphology, or in *E. latens* and *E. ecdysiastes*, both of which typically have broader adult leaves and can also be distinguished in the juvenile leaf phase (both species having larger, more spaced seedling and coppice leaves).

Intergrading populations between *E. lunata* and *E. olivina* occur to the north of the distribution of *E. lunata*, from near Kulin to south of Hyden. An intergrading population of *E. lunata* and *E. ecdysiastes* has been recoded near Newdegate.

Eucalyptus lunata grows in association with *E. dissimulata* (another species of *E.* ser. *Porantherae*) at some sites (e.g. north-east of Ongerup), but hybrids have not been recorded. *Eucalyptus dissimulata* can be distinguished from *E. lunata* by its more spaced, larger, green and non-pruinose seedling leaves, its broader adult leaves, and its generally larger buds and fruits.

Eucalyptus lunata has been widely planted around the world as *E.* 'Moon Lagoon', but has been less commonly planted in Australia. It is grown for amenity planting and especially for floriculture, where both its juvenile (coppice) foliage and its adult foliage with mature buds are used (Nicolle 2016).

Selected specimens

WESTERN AUSTRALIA (west to east). c. 1 km from Gillis Rd on Rabbit Proof Fence Rd to SE, 26 Jan. 2001, *D. Nicolle 3742 & M.E. French* (CANB, PERTH); W of Pingaring on Cargannocking-Pingaring Rd, 16 Sep. 2000, *D. Nicolle 3436 & M.E. French* (AD, CANB, PERTH); Dandagin Rd, NW Pingaring, 12 Apr. 2014, *M.E. French 2671* (PERTH); Dornock Rd, SW of Pingaring, 12 Apr. 2014, *M.E. French 2669* (PERTH); Moitch Creek, N of Borden-Bremer Bay Rd, 24 Mar. 2010, *D. Nicolle 5518 & M.E. French* (CANB, PERTH); c. 30 km N of Needilup just S of Rabbit Proof Fence Rd, 30 Nov. 1984, *M.I.H. Brooker 8749* (CANB, PERTH); Mallee Hill Rd, SE of Lake Grace, 11 Nov. 2015, *M.E. French 2831* (PERTH); Needilup Rd North, SE of Pingrup, 21 Oct. 2014, *M.E. French 2747* (PERTH); Lake Grace-Newdegate Rd, 22 Feb. 2014, *M.E. French 2655* (PERTH); Grant Williams Rd, SW of Newdegate, 11 Nov. 2015, *M.E. French 2828* (PERTH); Grant Williams Rd, SW of Newdegate, 11 Nov. 2015, *M.E. French 2829* (PERTH); Lake Bryde Recovery Catchment, Grant-Williams property, Roe Loc. 2552, Grant-Williams Rd, Remnant 52, 25 June 2003, *A. Coates 4671* (AD, PERTH); Sullivan Soak, Lake Magenta N.R., 30 July 2002, *D. Nicolle 4426 & M.I.H. Brooker* (CANB, PERTH); W of Reserve Rd on 'Moon Lagoon' tk, 23 Mar. 2010, *D. Nicolle 5510 & M.E. French* (CANB, PERTH); O'Neils Rd, NE of Jerramungup, upper Fitzgerald River, 28 Oct. 2018, *M.E. French 3066* (PERTH); Pabelup Drive, SW Fitzgerald River N.P., N of Bremer Bay, 16 Oct. 2018, *M.E. French 3060* (PERTH).

8. *Eucalyptus latens* Brooker

Nuytsia 6(3): 332, Figs 1, 2d, 3d (1988). — **Holotype:** 0.6 km south of Pike's road [Pikes Rd] north of North Bannister, 10 Oct. 1985, *M.I.H. Brooker 9046* (PERTH 01005510). **Isotypes:** AD99051210; AD98748208; CANB416431 [ex FRI]; MEL1610945; NSW.

Mallee to 4 m tall; lignotuber present, lignotuber resprouter (Nicolle 2006). *Bark* smooth throughout, decorticating annually in strips, grey over tan to pale grey. *Branchlets* non-pruinose. *Seedling leaves* opposite for 10–20+, nodes 5–20 mm apart, sessile or on petioles to 1 mm long, elliptic to lanceolate, 15–50 mm long × 8–15 mm wide, length:width ratio typically 2–4:1, slightly discolorous, dull, grey-green, pruinose on new growth. *Coppice leaves* similar but typically larger, more spaced and becoming disjunct. *Mature crown* composed entirely of adult leaves. *Adult leaves* with petioles 4–12 mm long, lamina (linear to) narrow-lanceolate to lanceolate, 35–85 mm long × 4–10 mm wide, length:width ratio typically 6–11:1, slightly to moderately glossy, green, non-pruinose; tertiary venation dense; oil glands numerous, connected to vein network (intersectional oil glands). *Inflorescences* 7–11-flowered; peduncles terete to angular, 4–9 mm long; pedicels 1–3 mm long. *Flower buds* ovoid to diamond-shaped, 5–8 mm long × 2–3 mm diam.; opercula bluntly conical to beaked, 2.5–4 mm long, length:width ratio typically 1–1.6:1. *Fruits* truncate-globose to shortly barrel-shaped, 4–5 mm long × 3–4.5 mm diam.; disc level to descending; valves 3, at rim level or below.

Diagnostic characters. Distinguished within *E.* ser. *Porantherae* by the following combination of characters: Lignotuberous mallee. Bark smooth and shedding throughout. Branchlets non-pruinose. Seedling leaves initially opposite, moderately-spaced, elliptic to lanceolate (length:width ratio 2–4:1), grey-green, new growth

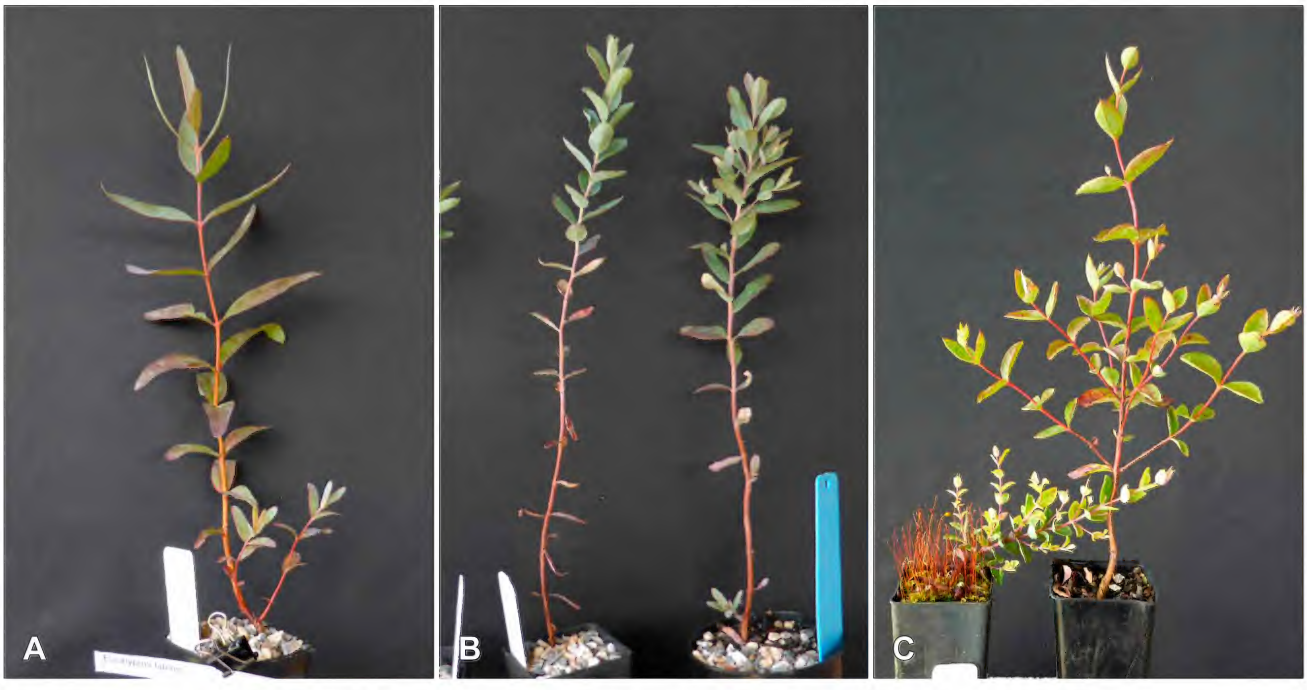

Fig. 19. *Eucalyptus latens* seedlings. **A** F1 of *D. Nicolle 1613*, Boyagin Rock N.R., W.A.; **B** F1 of *D. Nicolle 5070 & M.E. French*, S of Pikes Rd, W.A.; **C** F1 of *M.E. French 2602*, NE slope of Mt Talbot, SW of York, W.A.

pruinose (Fig. 19). Adult leaves usually narrow-lanceolate to lanceolate (length:width ratio 6–11:1), glossy and green at all ages. Pedicels distinct. Opercula bluntly conical to beaked. Fruit truncate-globose to shortly barrel-shaped.

Illustrations. M.I.H. Brooker & D.A. Kleinig, *Field Guide Eucalypts* 2: 301 (1990); 2nd edn, 2: 301 (2001); 3rd edn, 2: 274 (2016); A.V. Slee *et al.*, *EUCLID Eucalypts of Australia* CD ROM, *Eucalyptus latens* (2006); M.E. French, *Eucalypts W. Austral. Wheatbelt* 257 (2012), except seedling of *E.* sp. Sullivan Soak: Lake Magenta; M.E. French & D. Nicolle, *Eucalypts W. Austral. - S.W. Coast & Ranges* 216, 217 (2019).

Distribution and habitat. Endemic to W.A., where it is restricted to parts of the Darling Range and adjacent inland areas, from Mt Talbot (south-west of York) southwards to near Kojonup. The species is rarely common (Fig. 20). It grows on a variety of landscapes, from broad valleys to near granite outcrops high in the landscape, in gravelly loams and clays. It often forms a secondary-storey to taller woodland or forest eucalypts species. Associated eucalypts include *Corymbia calophylla*, *Eucalyptus accedens*, *E. aspersa*, *E. astringens* subsp. *astringens*, *E. drummondii*, *E. marginata* subsp. *marginata*, *E. salmonophloia* and *E. wandoo* subsp. *wandoo*.

Conservation status. Not yet assessed under the IUCN Red List of Threatened Species (IUCN 2020). Considering its known distribution, life cycle, and threats, we believe that an IUCN Red List category of 'Near Threatened' is appropriate for the species. Not a listed taxon under Conservation Codes for Western Australian Flora (Smith & Jones 2018). Recorded from Boyagin Rock Nature Reserve.

Common names. Secret Mallee (French 2012; Brooker & Kleinig 2016; French & Nicolle 2019), Narrow-leaved Red Mallee (French 2012; Brooker & Kleinig 2016).

Notes. *Eucalyptus latens* was originally described in 1985 from a single population in the jarrah / wandoo forest near North Bannister (Brooker 1988). Since that time, numerous other populations have been recorded scattered through the jarrah/wandoo forest on the edge of the Darling Range, as well as eastwards as far as the Newdegate area (French 2012; French & Nicolle 2019). We now regard *E. latens* as having a more restricted distribution, with more easterly-distributed populations (in the Kulin to Newdegate to Boxwood Hill area) attributable to other species, mostly *E. lunata* and *E. olivina*.

Selected specimens

WESTERN AUSTRALIA (north to south). Mt Talbot, SW of York, 3 Mar. 2013, *M.E. French 2602* (PERTH); Metro Rd, c. 1 km S of Brookton Hwy, 8 April 1988, *L. Robson s.n.* (PERTH 01345478); c. 1 km S of Pike's Rd, NE of North Bannister, 4 June 1986, *M.I.H. Brooker 9344* (CANB, PERTH); S of Pikes Rd, 8 Jan. 2007, *D. Nicolle 5070 & M.E. French* (AD, PERTH); Boyagin Rock N.R., 19 Jan. 1996, *D. Nicolle 1613* (AD, PERTH); NE section Boyagin N.R. (20610), 25 Sep. 1989, *K.J. Atkins 89017* (CANB, PERTH); adjacent to Old Wallis laydown area, Boddington shire, 2 Sep. 1997, *P. McNeil s.n.* (PERTH); Stoke's Block, Dryandra State Forest (S.F.), 27 June 1986, *M.I.H. Brooker 9364* (CANB, PERTH); Highbury Block B (Newman Block), Highbury S.F., 22 km S of Narrogin, 10 July 1989,

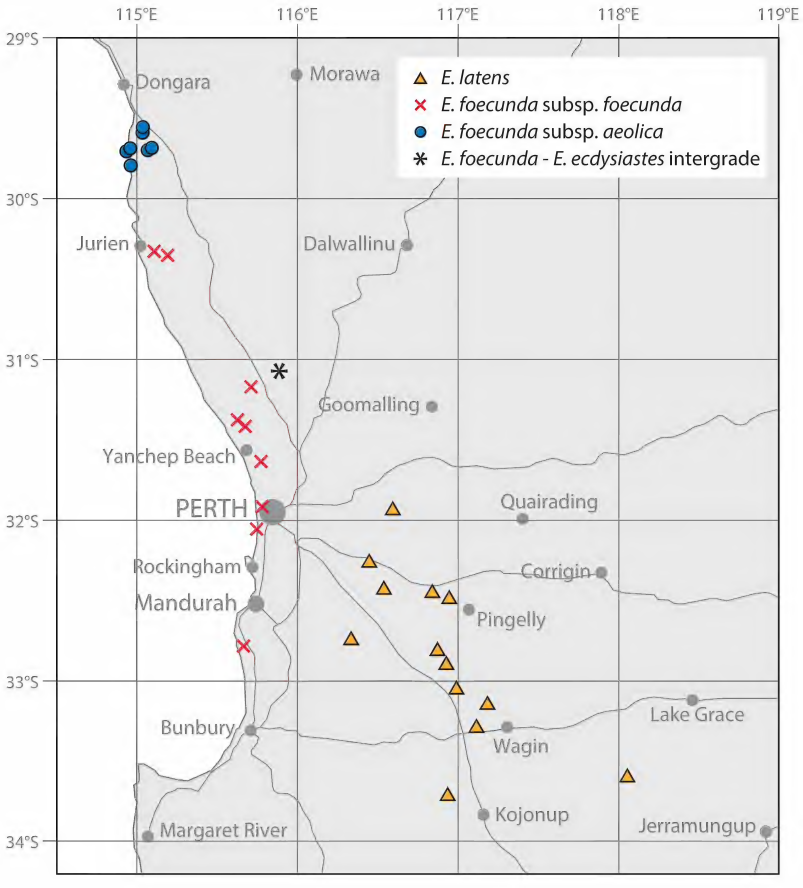

Fig. 20. Distribution of *Eucalyptus latens* and *E. foecunda* in Western Australia.

K.J. Atkins 89006 (PERTH); Fraser Rd, NE Arthur River, 3 Apr. 2009, *M.E. French 2127* (PERTH); c. 8 km from Nyabing along rd to Katanning, 16 Jan. 1979, *M.D. Crisp 5200* (CANB, NSW, PERTH).

9. *Eucalyptus foecunda* Schauer

in Lehm., *Pl. Preiss.* 1(1): 130 (1844). — **Type citation:** "In clivulis calcareis haud procul ab colonia Freemantle. Aug. M. 1839 fructifera. Herb. Preiss. No. 231". **Lectotype (here designated):** In clivulis calcareis haud longe ab urbiscula 'Freemantle' [Fremantle, W.A.], 13 Aug. 1839, *L.Preiss 231* (LD1033390). **Isolectotypes:** G; KW; L; MEL; NSW; P; S; W.

Mallee to 5 (rarely to 8) m tall; lignotuber present, lignotuber resprouter (Nicolle 2006). *Bark* rough on lower stems (to 1–3 m from the base), ribbony-fibrous to flaky-fibrous, grey, then smooth above, decorticating annually in strips, pale grey to pale tan over cream. *Branchlets* non-pruinose. *Seedling leaves* opposite for many pairs, nodes 9–25 mm apart, sessile or on petioles to 1 mm long, elliptic to narrow-lanceolate, 22–65 mm long × 6–15 mm wide, length:width ratio typically 2.5–6.5:1, slightly discolorous, dull to glossy, green to grey-green, new growth sometimes pruinose. *Coppice leaves* similar but typically larger, more spaced and becoming disjunct. *Mature crown* composed entirely of adult leaves. *Adult leaves* with petioles 5–14 mm long, lamina narrow-lanceolate to lanceolate, 48–90 mm long × 5–12 (–16) mm wide, length:width ratio typically 5.5–11:1, moderately glossy, green, non-pruinose; tertiary venation dense; oil glands numerous, connected to vein network (intersectional oil glands). *Inflorescences* 7–15-flowered; peduncles terete to very slightly flattened, 3.5–12 mm long; pedicels 1–5 mm long. *Flower buds* ovoid to fusiform, 6–10 mm long × 2.5–4 mm diam.; opercula conical to beaked, 3–5.5 mm long, length:width ratio typically 1–1.6:1. *Fruits* cupular to shortly barrel-shaped to slightly urceolate, 4–6 mm long × 4–6 mm diam.; disc near-level to steeply descending; valves 3, below rim level. **Fig. 21.**

Diagnostic characters. Distinguished within *E.* ser. *Porantherae* by the following combination of characters: Lignotuberous mallee. Bark non-shedding on lower trunks. Branchlets non-pruinose. Seedling leaves opposite, well-spaced, elliptic to narrow-lanceolate (length:width ratio 2.5–6.5:1), green to grey-green (Fig. 22). Adult leaves narrow-lanceolate to lanceolate (length:width ratio 5.5–11:1), glossy and green at all ages. Pedicels distinct. Opercula conical to beaked. Fruits cupular to shortly barrel-shaped to slightly urceolate.

Distribution and habitat. Endemic to W.A. A coastal species that is restricted to the west coast, from Cliff Head southwards to the Lake Preston area, inland to the Beermullah Plain (Fig. 20). It grows on pale-coloured coastal sands overlying limestone, often on limestony hills and dunes, in shrubland or open woodland.

Fig. 21. *Eucalyptus foecunda* habit. **A** subsp. *foecunda* (unvouchered, N of Seabird, W.A.); **B** subsp. *aeolica* (*D. Nicolle 7324 & M.E. French*, Beekeepers N.R., W.A.).

Conservation status. Globally listed as 'Least Concern' on the IUCN Red List of Threatened Species (IUCN 2020). We do not agree with this assessment and believe the species is significantly more threatened, as it has a relatively narrow coastal distribution north and south of Perth in an area at increasing risk from urbanisation and mineral extraction activities. Relatively few populations occur in reserves. Considering its known distribution, life cycle, and threats, we believe that an IUCN Red List category of 'Endangered' is more appropriate for the species.

Not a listed species under Conservation Codes for Western Australian Flora (Smith & Jones 2018).

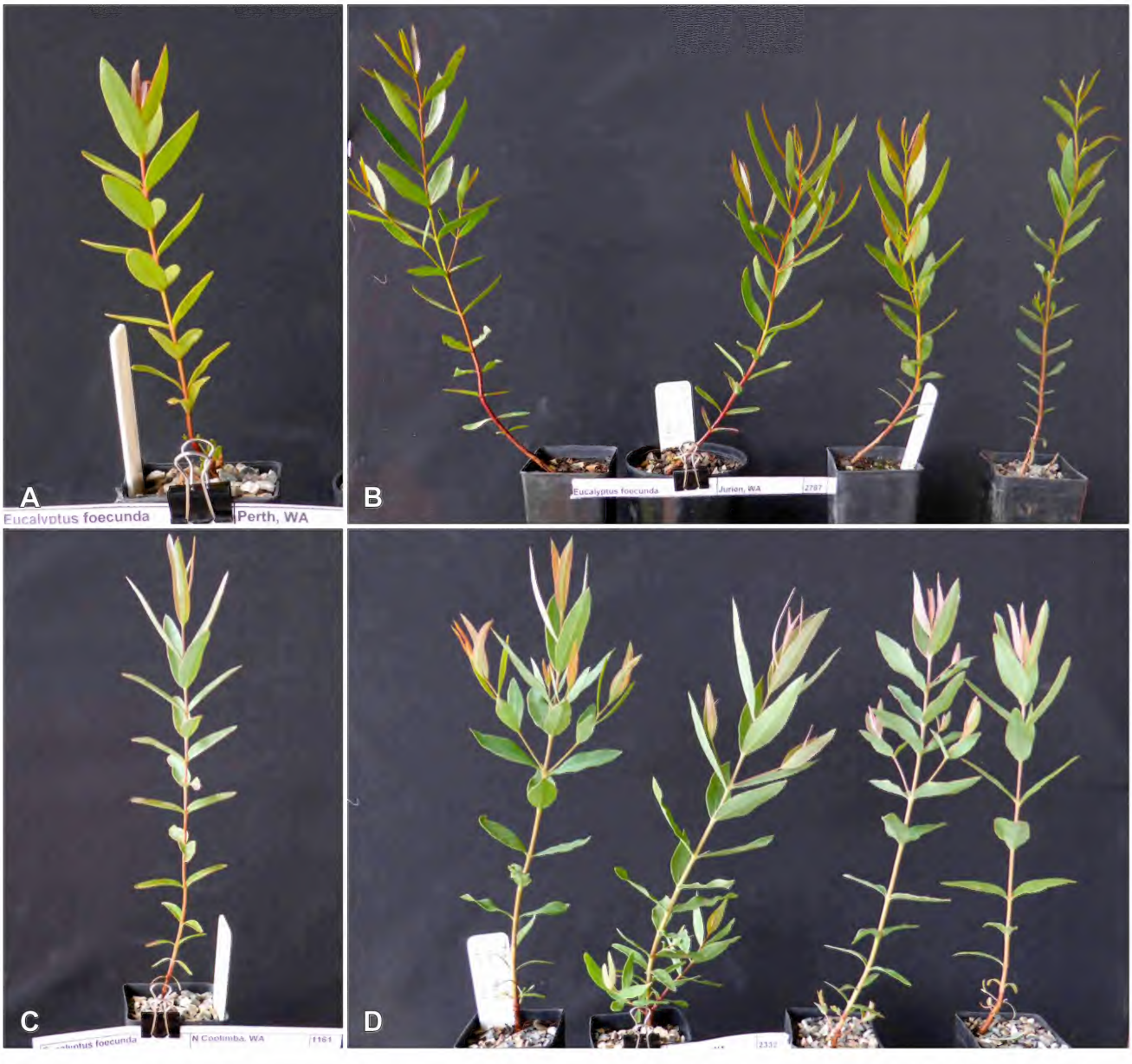

Fig. 22. *Eucalyptus foecunda* seedlings. **A** subsp. *foecunda* (F1 of *D. Nicolle 1152*, Bold Park, Perth, W.A.); **B** subsp. *foecunda* (F1 of *M.E. French 2787*, Cairn Rd, SE of Jurien, W.A.); **C** subsp. *aeolica* (F1 of *D. Nicolle 1161*, Indian Ocean Drive near Illlawong, W.A.); **D** subsp. *aeolica* (F1 of *M.E. French 2332*, Dempster Rd, SE of Dongara, W.A.).

We below suggest conservation codes for the two subspecies of *E. foecunda* using IUCN and Conservation Codes for Western Australian Flora assessment methodology.

Notes. *Eucalyptus foecunda* is a well-defined species and the only species of *E.* ser. *Porantherae* occurring within its distribution on the west coast between Geraldton and Augusta. It is a rough-barked mallee with elliptic to narrow-lanceolate seedling leaves, narrow-lanceolate to lanceolate, glossy, green adult leaves, and conical to beaked opercula. A population from south-west of Mogumber has seedling and adult morphology that is intermediate between *E. foecunda* and *E. ecdysiastes* and is regarded as an intergrading population.

Two geographic subspecies are recognised in *E. foecunda*, differing in their seedling leaf morphology. We cannot distinguish the two subspecies using adult material alone, although distribution is useful to discriminate them, with subsp. *foecunda* occurring from Jurien Bay southwards and subsp. *aeolica* occurring north of Jurien Bay.

9a. *Eucalyptus foecunda* Schauer subsp. *foecunda*

Eucalyptus leptophylla var. *leptorrhyncha* Blakely, *Key Eucalypts* 222 (1934); — **Type citation:** "W.A.– South of Freemantle, near the Newmarket Hotel. "Grows on Limestone country" (T.W.C. Schock), Subiaco Beach, Avon District, Cowcowing, Watheroo, Southern Cross, with smaller fruits than the type." **Lectotype (here designated):** South of Freemantle [Fremantle], near Newmarket Hotel [Western Australia], 9 Mar. 1920, *T.W.C. Schock 495* (NSW349547). **Isolectotype:** CANB [ex FRI].

Seedling leaves dull to glossy, green, non-pruinose. **Fig. 22.**

Diagnostic characters. Distinguished from *E. foecunda* subsp. *aeolica* by its dull to glossy, green, non-pruinose seedling leaves.

Illustrations. M.I.H. Brooker & D.A. Kleinig, *Field Guide Eucalypts* 2: 330 (1990); 2nd edn, 2: 330 (2001); 3rd edn, 2: 273 (2016); M.E. French & D. Nicolle, *Eucalypts W. Austral. – S.W. Coast & Ranges* 214, 215 (2019), bark, upper right flowers, seedling painting image.

Distribution and habitat. Endemic to W.A., where it is restricted to the west coast north and south of Perth, from Jurien Bay southwards to the Lake Preston area, inland to the Beermullah Plain (Fig. 20). It grows on yellowish coastal sands overlying limestone, often on limestony hills and dunes, in shrubland or very open woodland. Associated eucalypts include *Eucalyptus argutifolia*, *E. decipiens*, *E. gomphocephala* and *E. petrensis*.

Conservation status. Not yet assessed under the IUCN Red List of Threatened Species (IUCN 2020). Considering its known distribution, life cycle, and threats, we suggest an IUCN Red List category of 'Endangered' for the subspecies.

Not a listed taxon under Conservation Codes for Western Australian Flora (Smith & Jones 2018). The subspecies is poorly represented in reserves, and many populations are at increasing risk from urbanisation and from limestone, lime and sand mining operations. Recorded from Beeliar Regional Park and Bold Park in Perth, as well as from Leda Nature Reserve and Yalgorup and Yanchep national parks. We recommend that the conservation status of this subspecies be assessed in Western Australia, and suggest an interim code of VU (Vulnerable) using Conservation Codes for Western Australian Flora and Fauna criteria under the *Biodiversity Conservation Act 2016*.

Common names. Fremantle Mallee (Brooker & Kleinig 1990; Slee *et al.* 2006; French & Nicolle 2019), Coastal Dune Mallee (Brooker & Kleinig 1990; Slee *et al.* 2006).

Notes. *Eucalyptus foecunda* subsp. *foecunda* is distributed to the south of subsp. *aeolica*. Intermediates between the two subspecies are not known, but cannot be recognised using adult material alone, and thus are not easily identified. Such intergrades may occur between the respective distribution of the two subspecies, in the area between Leeman and Jurien Bay.

Selected specimens

WESTERN AUSTRALIA (north to south). E of Jurien, N of Hill River, 2 June 2016, *M.E. French 2864* (PERTH); Cairn Rd, SE of Jurien, 28 June 2015, *M.E. French 2787* (PERTH); c. 4–5 km NW to turnoff to Wabling Hill on Lancelin rd, 16 May 1984, *M.I.H. Brooker 8612* (CANB, PERTH); Pinpin Rd, Beermullah Plain, 27 Mar. 2010, *D. Nicolle 5545 & M.E. French* (AD, CANB, PERTH); The Boulevard, opposite Golf Course Tavern rd, 11 Dec. 1984, *M.I.H. Brooker 8754* (AD, CANB, PERTH); Bold Park, Perth, 25 Nov. 1994, *D. Nicolle 1152 & M.E. French* (AD).

9b. *Eucalyptus foecunda* subsp. *aeolica* D.Nicolle & M.E.French, *subsp. nov.*

Holotypus: Western Australia, 1.4 km east of Indian Ocean Drive on Beekeepers Rd, Beekeepers Nature Reserve, 16 May 2017, *D. Nicolle 7322 & M.E. French* (PERTH09199020). **Isotypi:** AD; CANB.

This subspecies had previously been recognised under the designation *Eucalyptus* 'aeolica' (W.A. Herbarium 2019), but a name was never formally published. We have assigned subspecific rank for this taxon, as its differences from the more southerly-distributed typical *E. foecunda* are slight and are only apparent in the juvenile growth phase.

Seedling leaves dull, grey-green, pruinose, at least on new growth. **Fig. 22.**

Diagnostic characters. Distinguished from *E. foecunda* subsp. *foecunda* by its consistently dull, grey-green seedling leaves that are pruinose, at least on the new growth.

Illustrations. M.E. French & D. Nicolle, *Eucalypts W. Austral. - S.W. Coast & Ranges* 215 (2019), habit image.

Distribution and habitat. Endemic to W.A., where it is restricted to the west coast between Cliff Head and Leeman, extending no more than about 15 km inland (Fig. 20). It grows on white, yellowish or pale brown coastal sands overlying limestone, often on limestony dunes, in mallee shrubland or low open woodland. Associated eucalypts include *Eucalyptus erythrocorys*, *E. obtusiflora* subsp. *dongarrensis*, *E. petrensis* and *E. zopherophloia*.

Conservation status. Not yet assessed under the IUCN Red List of Threatened Species (IUCN 2020). Considering its known distribution, life cycle, and threats, we suggest an IUCN Red List category of 'Endangered' for the subspecies.

Not currently a listed taxon under Conservation Codes for Western Australian Flora (Smith & Jones 2018). Recorded from Beekeepers Nature Reserve. We recommend that the conservation status of this subspecies be assessed in Western Australia, and suggest an interim code of VU (Vulnerable) using Conservation Codes for Western Australian Flora and Fauna criteria under the *Biodiversity Conservation Act 2016*.

Etymology. The epithet is from the Greek *aeolica* (the Greek god Aeolus, ruler of the winds) and the suffix *-icus* (pertaining to), referring to its distribution on the wind-swept dunes of the west coast.

Common names. We suggest the common name 'Beekeepers Mallee'.

Notes. *Eucalyptus foecunda* subsp. *aeolica* is distributed to the north of subsp. *foecunda*, and differs in its consistently dull, grey-green seedling leaves that are pruinose, at least on the new growth. Intermediates between the two subspecies are not known, but cannot be recognised using adult material alone, and thus are not easily identified. Such intergrades may occur between the respective distribution of the two subspecies, in the area between Leeman and Jurien Bay.

Selected specimens

WESTERN AUSTRALIA (north to south). Indian Ocean Drive near Illlawong, 26 Nov. 1994, *D. Nicolle 1161* (AD); c. 15 km N of Coolimba crossroads on coastal rd, 23 Feb. 2000, *M.I.H. Brooker 13121* (AD, CANB, PERTH); c. 14 km N of Coolimba on Cliff Head rd, 21 Nov. 1986, *M.I.H. Brooker 9555a* (AD); c. 14 km N of Coolimba on Cliff Head road, 21 Nov. 1986, *M.I.H. Brooker 9556* (AD); W of Brand Hwy, NW of Arrowsmith Hill, 30 Aug. 1998, *M.E. French 664* (AD, PERTH); Dempster Rd, Arrowsmith, SE of Dongara, 29 Sep. 2012, *M.E. French 2332* (PERTH); c. 14 km E of Indian Ocean Drive on Beekeepers Rd, Beekeepers N.R., 16 May 2017, *D. Nicolle 7324 & M.E. French* (PERTH); on W extension of Beekeepers Rd, c. 14 km to Indian Ocean Drive, Beekeepers N.R., NW of Eneabba, 14 Sep. 2016, *M.E. French 2878* (PERTH).

10. *Eucalyptus leptophylla* F.Muell. ex Miq.

Ned. Kruidk. Arch. 4(1): 123 (1856). — **Type citation:** "Nova Hollandia australis Murray-scrub, aestate florens (Dr Behr)". **First-step lectotype:** Nova Hollandia australis Murray-scrub, aestate florens, *s.dat.*, *H. Behr s.n.* (U), *fide* Chippend., *Fl. Australia* 19: 281 (1988), as "holo". **Second-step lectotype (here designated):** U1438377, left-hand branchlet only. **Residual syntypes:** FI; MEL231957; MEL1607365. **Epitype (here designated):** South Australia, Sleeper Track, S boundary of Swan Reach Conservation Park, SW of Swan Reach, *D. Nicolle 8039*, 7 Mar. 2021 (AD). **Isoepitypes:** CANB; NSW; PERTH.

Eucalyptus leptophylla var. *densa* Blakely, *Key Eucalypts* 222 (1934). — **Type citation:** "N.S.W. – Nymagee, J. L. Boorman, October, 1903". **Lectotype:** Nymagee, Oct. 1903, *J.L. Boorman s.n.* (NSW42244), *fide* Chippend., *Fl. Australia* 19: 281–282 (1988), as "holo". **Isotypes:** A00069050; BM001015308; BM 001015309; CANB412834; K; US00409811.

Mallee to 7 m tall; lignotuber present, lignotuber resprouter (Nicolle 2006). *Bark* usually smooth throughout (sometimes with some loose persistent bark on the lower trunks), coppery to grey over cream, decorticating annually in strips. *Branchlets* non-pruinose. *Seedling leaves* opposite for numerous pairs, nodes 6–25 mm apart, sessile, narrowly elliptic to ovate, 10–35 mm long × 5–18 mm wide, length:width ratio typically 1.3–3.8:1, slightly discolorous, dull to slightly glossy, green to grey-green, new growth often pruinose. *Coppice leaves* similar but typically larger, more spaced and eventually becoming disjunct. *Mature crown* composed entirely of adult leaves. *Adult leaves* with petioles 6–12 mm long, lamina narrow-lanceolate to lanceolate, 40–80 mm long × 3.5–11 mm wide, length:width ratio typically 6.5–11.5:1, glossy, green, non-pruinose; tertiary venation dense; oil glands numerous, connected to vein network (intersectional oil glands). *Inflorescences* 7–13-flowered; peduncles terete to slightly angular, 6–9 mm long; pedicels 1–4 mm long. *Flower buds* ovoid to fusiform or somewhat diamond-shaped, 5–7 mm long × 2.5–4.5 mm diam.; opercula hemispherical to conical (to slightly beaked), 2–4 mm long, length:width ratio typically 0.8–1.2:1. *Fruits* truncate-globose to cupular to shortly barrel-shaped or slightly obconic, 4–5 mm long × 4–5 mm diam.; disc near level to steeply descending; valves 3 or 4, at or below rim level.

Diagnostic characters. Distinguished within *E.* ser. *Porantherae* by the following combination of characters: Lignotuberous mallee. Bark usually smooth throughout. Branchlets non-pruinose. Seedling leaves opposite, moderately-spaced, narrowly elliptic to ovate (length:width ratio 1.3–3.8:1), generally not or slightly pruinose except on new growth (Fig. 23). Adult leaves narrow-lanceolate to lanceolate (length:width ratio 6.5–11.5:1), glossy and green at all ages. Pedicels short but distinct. Opercula rounded to sharply conical. Fruits truncate-globose to cupular to shortly barrel-shaped or slightly obconic.

Typification. The original material for *Eucalyptus leptophylla* was collected by Hans Hermann Behr from 'Murray-scrub', which is between present day Barossa Valley and the Murray River in South Australia (Kraehenbuehl 1981). Within that area, *E. leptophylla* is quite rare, while the superficially similar but distantly related *E. odorata* Behr (from *E.* sect. *Adnataria*) is relatively common.

The earliest mention of a type for *E. leptophylla* is that of Maiden (1922), who stated that his illustrations (drawn by Margaret Flockton) were 'drawn from the type' but did not indicate where that material was held. None of these illustrations are based on material originating from the Murray-scrub nor do they match later-mentioned specimens, and all are ambiguous with regard to their identity.

The next mention of a type is by Brooker (1979), who states that he examined type material in FI and U and indicates in a figure caption that the U specimen is an 'isotype' (Brooker 1979: 154, Fig. 39). However, Brooker did not explicitly mention a holotype or designate a lectotype. The FI material is undoubtedly *E. leptophylla*. The U material consists of two sheets. One of these (U1436878) consists of a single flowering twig that is not *E. leptophylla*, but is most likely *E. odorata*. The other sheet (U1438377) has two pieces that appear to be different from one another: the right-hand branchlet with immature buds matches U1436878 (i.e. is most likely *E. odorata*), while the

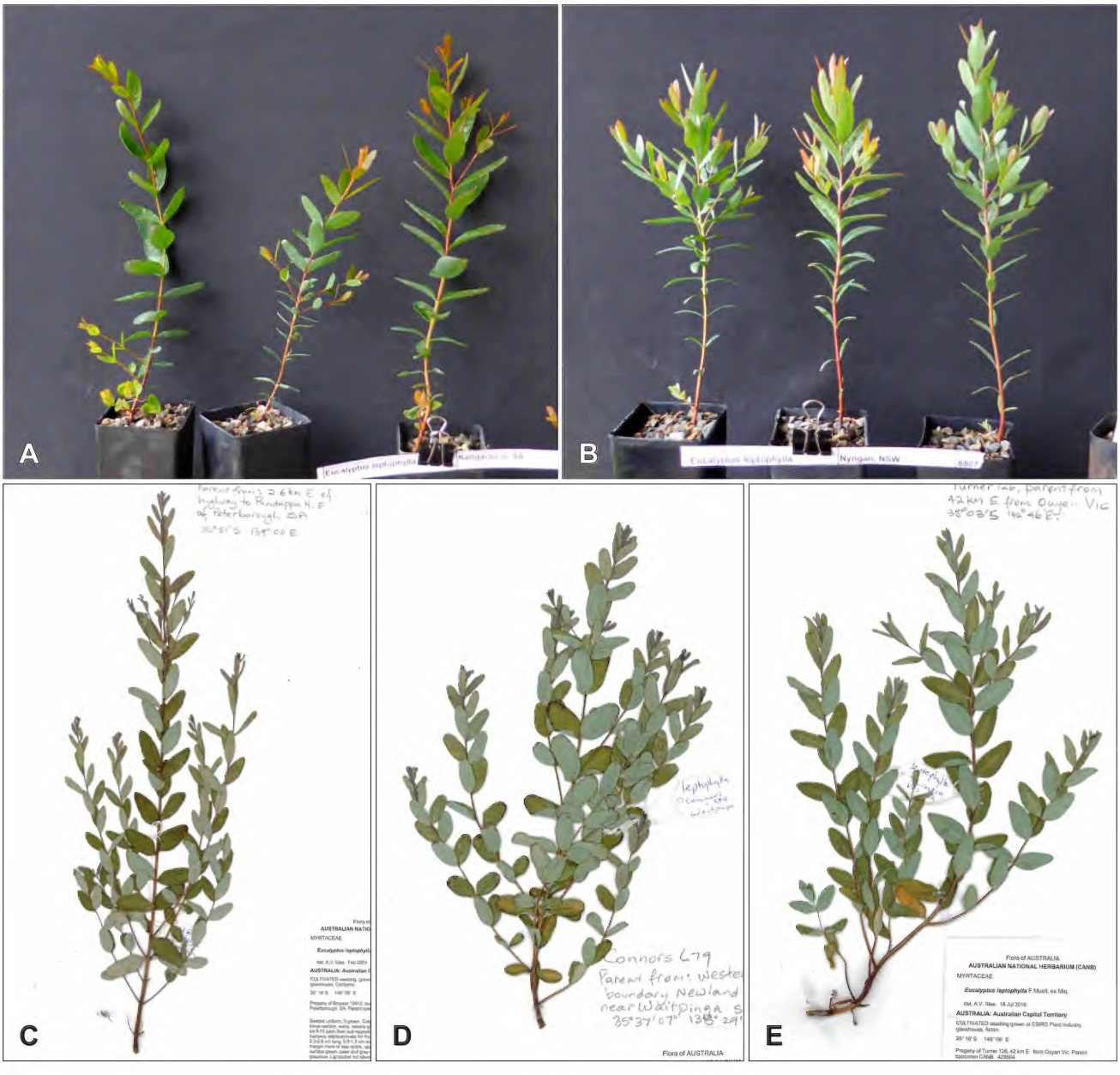

Fig. 23. *Eucalyptus leptophylla* seedlings. **A** F1 of *D. Nicolle 4736 & M.I.H. Brooker*, Cape Hart Rd, Kangaroo Island, S.A.; **B** F1 of *D. Nicolle 6807*, W of Nymagee on Cobar Rd, N.S.W.; **C** F1 of *M.I.H. Brooker 12612*, E of Peterborough, S.A.; **D** F1 of *J. Connors 679*, Newland Head C.P., Waitpinga, S.A.; **E** F1 of *J.D. Turner 126 & H. Vos*, E of Ouyen towards Manangatang, Vic.

larger left-hand branchlet with fruits is different, and *may* be *E. leptophylla*.

Chippendale (1988) inadvertently lectotypified *E. leptophylla* by stating that the 'holo' was held at U, without reference to any other type material. This citation is correctable to "lectotype" following Art. 9.10 of the *International Code of Nomenclature for algae, fungi, and plants* (Turland *et al.* 2018).

Although not listed in any publications as far as we know, there are two sheets in MEL labelled as 'isotype'. The sheets cross-reference each other so can be treated as a single gathering. Although both MEL sheets were seen and determined by Ian Brooker in 1993 as *E. leptophylla*, they are not actually that species, but are again most likely *E. odorata*, and also match well with U1436878.

We here restrict Chippendale's lectotype to the left-hand branchlet only on U1438377. We regard the right-hand branchlet on U1438377 as representative of *E. odorata* and exclude this material from secondary lectotypification. We also regard U1436878 and the MEL material to be representative of *E. odorata*. The FI material is undoubtedly *E. leptophylla*, but has the status of a remaining syntype following lectotypification.

Because Chippendale's lectotype is mixed and the part that may represent *E. leptophylla* (the left-hand branchlet on sheet U1438377, secondarily lectotypified here) is ambiguous based on the available character evidence, we have designated the Swan Reach collection

above as an epitype for *E. leptophylla*. This gathering, made specifically for the purpose of an epitype, is from the general region of Behr's original material (noting that *E. leptophylla* is rare in that region). The epitype consists of multiple duplicates of fertile material from a population of 'typical-concept' *E. leptophylla* with a GPS-recorded location within a Conservation Park.

Illustrations. M.I.H. Brooker & D.A. Kleinig, *Field Guide Eucalypts* 2: 302 (1990); 2nd edn, 2: 302 (2001); 3rd edn, 2: 275 (2016); A.V. Slee *et al.*, *EUCLID Eucalypts of Australia* CD ROM, *Eucalyptus leptophylla* (2006); D. Nicolle, *Native Eucalypts S. Austral.* 94, 95 (2013).

Distribution and habitat. Widespread throughout much of southern S.A., north-western Vic. and western N.S.W., from the south coast near Nullarbor roadhouse in S.A. eastwards, including most of Eyre and Yorke peninsulas and parts of Fleurieu Peninsula and Kangaroo Island, eastwards into north-western Vic. as far as Inglewood, and into south-western N.S.W. as far as Nymagee and West Wyalong. Small, isolated populations occur as far inland as Wilpena Pound in S.A. and south-east of Wilcannia in N.S.W. (Fig. 24). It grows on a variety of landscapes and soils, but most commonly on pale-coloured sandy soils with other sand-loving species. It typically occurs as a component of mallee shrubland vegetation. Associated eucalypts include *Eucalyptus albopurpurea*, *E. angulosa*, *E. arenacea*, *E. behriana*, *E. brachycalyx*, *E. calcareana*, *E. calycogona* subspp. *calycogona*, *spaffordii* and *trachybasis*, *E. cneorifolia*, *E. cosmophylla*, *E. cyanophylla*, *E. diversifolia* subsp. *diversifolia*, *E. dumosa*, *E. fasciculosa*, *E. froggattii*, *E. gracilis*, *E. incrassata*, *E. leucoxylon* subsp. *stephaniae*, *E. odorata*, *E. oleosa* subspp. *ampliata* and *oleosa*, *E. peninsularis*, *E. phenax* subsp. *phenax*, *E. sabulosa*, *E. socialis* subspp. *socialis* and *viridans*, *E. wimmerensis* and *E. yalatensis*.

Conservation status. Globally listed as 'Vulnerable' on the IUCN Red List of Threatened Species (IUCN 2020). We do not agree with this assessment, as the species is widespread in parts of S.A., Vic. and N.S.W., is relatively common throughout much of its distribution, and is well represented in numerous reserves in all three States. Considering its known distribution, life cycle, and threats, we believe that an IUCN Red List category of 'Least Concern' is more appropriate for the species.

The species is not listed as a threatened taxon nationally or by any State. The species has been recorded in S.A. from Bascombe Well, Billiatt, Black Hill, Cox Scrub, Ferries-McDonald, Hambidge, Heggaton, Hincks, Messent, Mount Boothby, Newland Head, Ngarkat, Peebinga, Seal Bay, Swan Reach and Yeldulknie conservation parks. In Vic. it is recorded in Hattah-Kulkyne, Little Desert, Murray-Sunset, and Wyperfeld national parks and Mount Arapiles-Tooan State Park. In N.S.W. it is recorded in Mallee Cliffs, Mungo, and Tarawi national parks and Nombinnie, Woggoon, and Yathong nature reserves.

Common names. March Mallee (Nicolle 2013), Narrow-leaved Red Mallee (Brooker & Kleinig 1990; Slee *et al.* 2006; Nicolle 2013), Slender-leaved mallee (Slee *et al.* 2006).

Notes. The seedling morphology of *E. leptophylla* is somewhat variable and appears to follow a geographical basis. Generally the seedling leaves are narrowest and greyest at the north-eastern end of its distribution (the Nymagee area in N.S.W.), and broadest and greenest in the south, particularly on Kangaroo Island in S.A. Brooker (1979) also noted that progeny of *E. leptophylla* from Kangaroo Island, as well as those from Athelstone (in the South Mount Lofty Ranges of S.A.) are green. Further population-based seedling trials of *E. leptophylla* are required to ascertain if the Kangaroo Island and

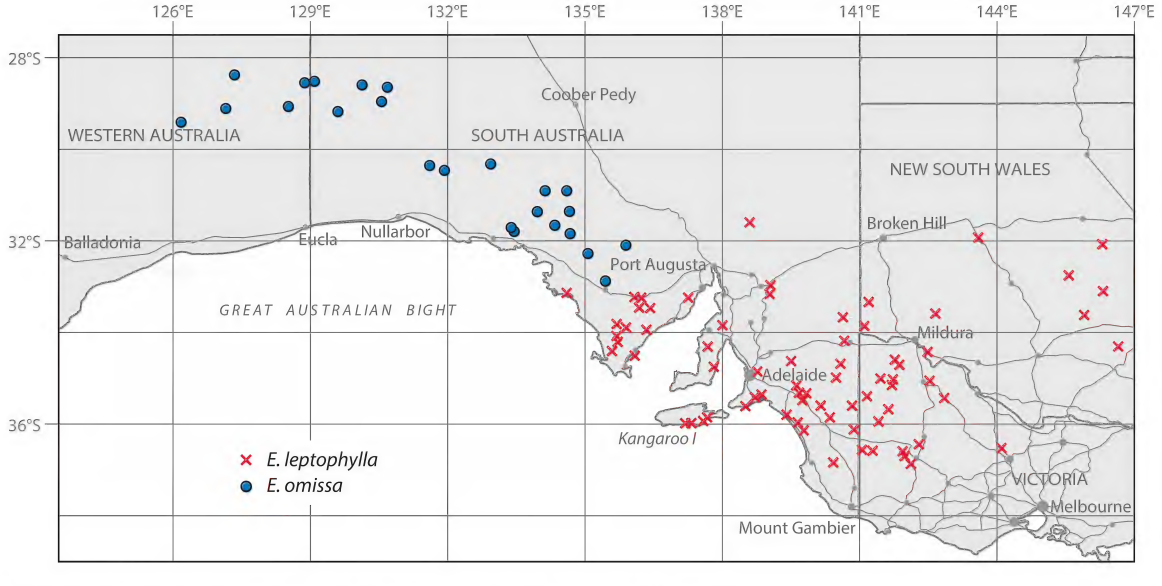

Fig. 24. Distribution of *Eucalyptus leptophylla* and *E. omissa* in southern Australia.

South Mount Lofty Ranges populations are worthy of taxonomic distinction.

Although Nicolle (2013) treated *E. omissa* (as *E.* sp. Great Victoria Desert) as separate from *E. leptophylla* in his treatment of all S.A. eucalypts, his distribution map of *E. leptophylla* erroneously illustrated that species extending into W.A. in the Eucla area on the south-coast. We have not been able to verify any specimens of *E. leptophylla* from the Eucla area, and do not regard it being present in W.A.

Selected specimens

SOUTH AUSTRALIA (west to east). Cape Hart Rd, Kangaroo Island, 10 Feb. 2004, *D. Nicolle 4737 & M.I.H. Brooker* (AD, CANB); Three Chain Rd, Kangaroo Island, 29 Apr. 1994, *D. Nicolle 794* (AD); c. 30 m east from the western boundary of the Newland Head Conservation Park (C.P.), Waitpinga, 3 Oct. 1997, *J.R. Connors 679* (CANB); 2.6 km E of hwy towards Pandappa Hill, E of Peterborough, 28 Aug. 1996, *M.I.H. Brooker 12612* (AD, CANB, MEL); Messent C.P., near the SE corner, E of Salt Creek on Coorong, 13 May 1993, *M.I.H. Brooker 11530* (AD, CANB, MEL, NSW).

VICTORIA (west to east). 22.8 km S from Hwy 8 (Kaniva to Nhill) towards Lemon Springs, Little Desert, 13 July 1993, *D. Nicolle 447* (AD); 6 km N of Dimboola to Jeparit, 15 Sep. 1977, *J.D. Turner & H. Vos 114* (AD, CANB, MEL, NSW); 46 km N Dimboola–Rainbow, 1 km down side track, 15 Sep. 1977, *J.D. Turner & H. Vos 115* (CANB); 21 km S Ouyen, 15 Sep. 1977, *J.D. Turner & H. Vos 120* (CANB); 12 km E of Ouyen to Manangatang, 16 Sep. 1977, *J.D. Turner & H. Vos 121* (AD, CANB, MEL, NSW); 42 km E of Ouyen to Manangatang, 16 Sep. 1977, *J.D. Turner & H. Vos 126* (CANB).

NEW SOUTH WALES (west to east): 5.8 km W from Rufus River Rd on rd to Renmark, 10 Oct. 1989, *M.I.H. Brooker 10314* (AD, CANB, MEL, NSW); State Survey Mark no. 4303, Sturt Hwy between Mildura and Euston, 30 July 1994, *D. Nicolle 982* (AD); Yathong N.R., via Mt Hope, along central fire trail, 15 Aug. 1979, *A. Slee & M. Holgate 179* (CANB); c. 15 km W of Euabalong West towards Matakana on tk along S side of railway line, 14 Nov. 1989, *M.I.H. Brooker 10355* (AD, CANB, MEL, NSW); c. 5 km W of Nymagee on Cobar Rd, 27 May 2014, *D. Nicolle 6807* (AD, CANB).

11. *Eucalyptus omissa* D.Nicolle & M.E.French, *sp. nov.*

Holotypus: South Australia, Dog Fence, NW of Lake Everard, 25 Nov. 2020, *D. Nicolle 7966* (AD286726). **Isotypus:** CANB.

Eucalyptus sp. Great Victoria Desert (*D. Nicolle & M. French DN 3877*), *p.p. max.*: D.Nicolle *et al.*, *Nuytsia* 22(3): 103 (2012).

Eucalyptus sp. Great Victoria Desert: D.Nicolle: *Native Eucalypts S. Austral.* 96–97 (2013).

Mallee to 9 m tall; lignotuber present, lignotuber resprouter (Nicolle 2006). *Bark* usually persistent up to 2 m, loose, flaky or ribbony, grey, then smooth above (sometimes smooth throughout), pale coppery to pale tan over cream, decorticating annually in strips. *Branchlets* non-pruinose except on juvenile or intermediate growth within canopy. *Seedling leaves* opposite for numerous pairs, nodes 15–30 mm apart, sessile, elliptic or ovate to near orbicular or cordate, 11–30 mm long × 8–20 mm wide, length:width ratio typically 1–1.7:1, slightly discolorous, dull, grey-green to grey, pruinose, seedling stems typically minutely warty. *Coppice leaves* similar but typically larger, more spaced and eventually becoming disjunct. *Mature crown* commonly composed of a mixture of juvenile, intermediate and adult leaves, or sometimes entirely of either juvenile or adult leaves. *Adult leaves* with petioles 2–11 mm long, lamina narrow-lanceolate to broad-lanceolate, 30–78 mm long × 4–12 (–15) mm wide, length:width ratio typically 4–10:1, glossy, green to light green, non-pruinose; tertiary venation dense; oil glands numerous, connected to vein network (intersectional oil glands). *Inflorescences* 7–13-flowered; peduncles terete to slightly angular in cross section, 4–8 mm long; pedicels 1–4 mm long. *Flower buds* ovoid to fusiform to diamond-shaped, 4–7 mm long × 2.5–3.5 mm diam.; opercula almost rounded to conical or slightly beaked, 2–5 mm long, length:width ratio typically 0.9–1.5:1. *Fruits* truncate-globose to cupular to shortly barrel-shaped or somewhat obconic, 3.5–5 mm long × 3–5 mm diam.; disc near level to steeply descending; valves 3 (4), at or below rim level.

Diagnostic characters. Distinguished within *E.* ser. *Porantherae* by the following combination of characters: Lignotuberous mallee. Bark usually loose, ribbony or flaky on lower stems (sometimes smooth throughout). Branchlets non-pruinose except on juvenile or intermediate growth within canopy. Seedling leaves opposite, moderately-spaced, elliptic or ovate to near orbicular or cordate (length:width ratio typically 1–1.7:1), greyish, pruinose (Fig. 25). Adult leaves narrow-lanceolate to broad-lanceolate (length:width ratio typically 4.5–8.5:1), glossy and green at all ages. Pedicels short but distinct. Opercula almost rounded to conical or slightly beaked. Fruits truncate-globose to cupular to shortly barrel-shaped or somewhat obconic.

Illustrations. D. Nicolle, *Native Eucalypts S. Austral.* 97 (2013); the seedling painting reproduced on p. 96 represents *E. ecdysiastes* and not *E. omissa*.

Distribution and habitat. Widespread through the central and southern Great Victoria Desert in S.A. and W.A., extending west to Jubilee Lakes and the Neale Junction area in W.A. and south-east to Yumbarra and Pureba conservation parks in S.A., south-east of which it appears to grade into *E. leptophylla* (Fig. 24). It is restricted to red to pale yellow desert sands, where it occurs as a component of mallee shrubland or low open woodland, and often on aeolian sand dunes around claypans and mostly dry salt lakes. Associated eucalypts include *Eucalyptus concinna*, *E. eremicola* subsp. *peeneri*, *E. gracilis*, *E. gongylocarpa*, *E. gypsophila*, *E. mannensis*

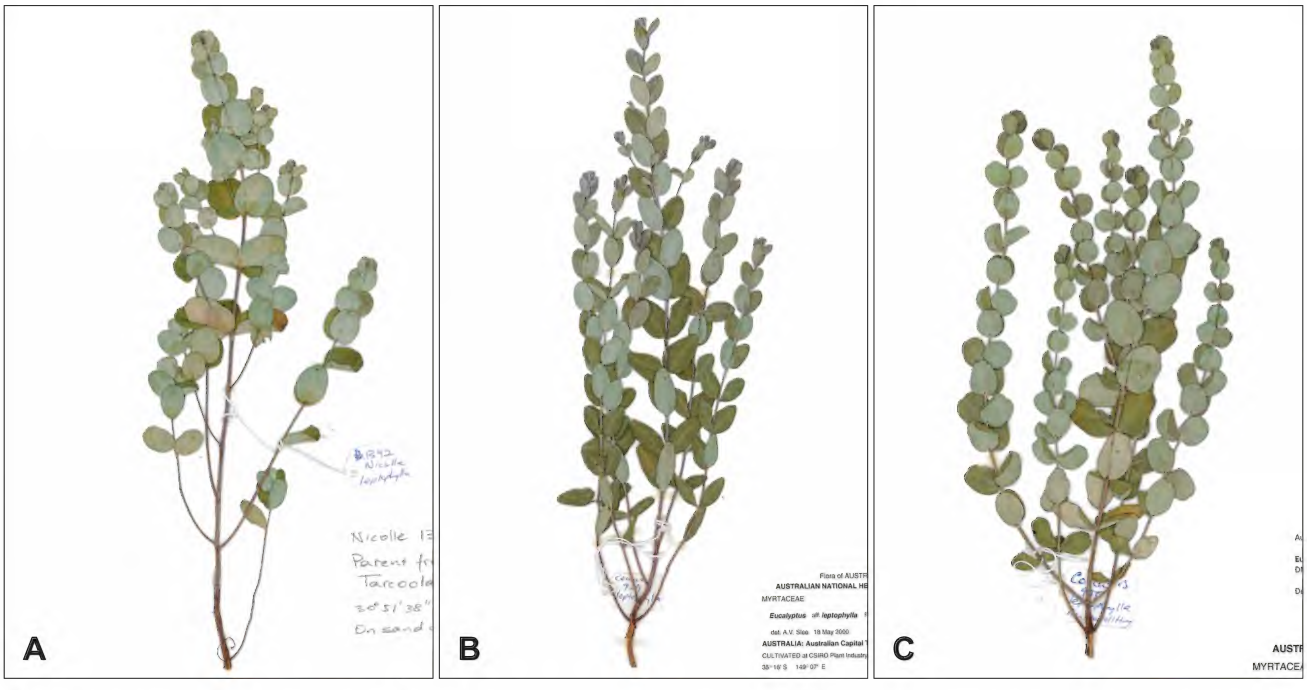

Fig. 25. *Eucalyptus omissa* seedlings. **A** F1 of *D. Nicolle 1392*, S of Tarcoola, S.A.; **B** F1 of *J. Connors 929 & D. Nicolle*, N of Oak Valley turnoff on Cook to Vokes Hill track, S.A.; **C** F1 of *J. Connors 955 & D. Nicolle*, Ann Beadell Hwy, Great Victoria Desert, W.A.

subsp. *mannensis*, *E. oleosa*, *E. socialis* subsp. *victoriensis*, *E. trivalva* and *E. youngiana*.

Conservation status. Not yet assessed under the IUCN Red List of Threatened Species (IUCN 2020). Considering its known distribution, life cycle, and threats, we believe that an IUCN Red List category of 'Least Concern' is appropriate.

Not listed as threatened in W.A. or S.A. The species is relatively common over a large, remote area, and is not considered to be at risk. In S.A. it is recorded from Mamungari (Unnamed), Pureba and Yumbarra conservation parks and Yellabinna Regional Reserve. In W.A. it has been recorded from Great Victoria Desert and Neale Junction nature reserves.

Etymology. From the Latin *omissus* (neglected, forgotten), referring to the relatively few collections of the species, despite its widespread distribution spanning the sparsely-populated Great Victoria Desert.

Common names. Narrow-leaved Red Mallee (Nicolle 2013).

Notes. Previously included in *E. leptophylla*, from which it differs most notably in its seedling morphology, which have more rounded, greyer and consistently strongly pruinose leaves and minutely warty stems. *Eucalyptus omissa* also differs from *E. leptophylla* in often having persistent bark on the lower trunks, in often having a canopy composed partly of juvenile and intermediate foliage, and in its adult leaves which have a shorter length:width ratio. These bark, canopy, adult leaf and bud characteristics are more variable and thus less reliable than the seedling morphology in distinguishing *E. omissa*. Intergrades between *E. omissa* and *E. leptophylla* occur at the southern fringe of the Great Victoria Desert in S.A., in a thin band from about Koonibba (north of Ceduna) eastwards to near the Gawler Ranges.

Eucalyptus omissa appears to morphologically and geographically link the westerly-distributed *E. horistes* group (*E. horistes*, *E. ecdysiastes*, *E. fruticosa* and *E. efflorescens*) with the easterly-distributed *E. leptophylla*. The seedling morphology of *E. omissa* is very similar to that of the *E. horistes* group, and shares with *E. fruticosa* and *E. efflorescens* the common presence of juvenile and intermediate foliage partially forming the mature canopy of the plant. Nonetheless, *E. omissa* has historically been included in *E. leptophylla* due to its similarity in adult morphology. We consider *E. omissa* to be equally related to both the *E. horistes* group and to *E. leptophylla* (geographically and morphologically linking the two), and therefore believe that specific status is appropriate for the taxon.

Almost all specimens bearing the phrase name *E.* sp. Great Victoria Desert (Nicolle *et al.* 2012) are applicable to *E. omissa*, and our concept of that phrase name also applies to that species (hence "*p.p. max.*"). However, the reference specimen for the phrase name (*D. Nicolle 3877 & M. French*) is actually *E. ecdysiastes* (hence "*p.p. min.*", below).

Selected specimens

WESTERN AUSTRALIA (west to east). SW of Jubilee Lakes, 28 Sep. 1993, *D. Nicolle 505* (AD, CANB, PERTH); private rd, N of Tjuntjuntjara Community, S Great Victoria Desert, E of Connie Sue Hwy, 24 June 2008, *M.E. French*

2111 (PERTH); c. 185 km W by rd from the W.A./S.A. border towards Neale Junction on the Anne Beadell Hwy, Great Victoria Desert, 10 July 1999, *D. Nicolle 2670 & J. Connors* (AD); Great Victoria Desert, c. 185.3 km W of the S.A./W.A. border on the Ann Beadell Hwy, 10 July 1999, *J.R. Connors 955 & D. Nicolle* (PERTH, CANB, NSW); 19 km W of Ilkurlka, E of Neale Junction on Anne Beadell Hwy, 30 Mar. 2013, *M.E. French 2618* (PERTH); 178 km W of Vokes Hill junction, 7 km E of Camp 6 (Serpentine Lakes), 26 Aug. 1980, *C.R. Alcock 8320* (AD); 1 km S of the N boundary of Great Victoria Desert N.R., 1.5 km SW of exploration tk, 140 km ENE of Tjuntjuntjara, 200 km N of Forrest and 47 km W of the S.A. border, 23 Mar. 2012, *D. Coultas & J. Grantham C2-62-04* (PERTH).

SOUTH AUSTRALIA (west to east). Between S.A. border & Tidilchurra Rockhole, 26 Aug. 1980, *D. Symon 12641* (AD, CANB, NSW); 30 km N of Aboriginal Business Rd, 1.5 km W of made rd, 21 May 2014, *D.E. Murfet 7729* (AD); Unnamed C.P., 56 km W of Vokes Corner, 27 Aug. 1980, *N.N. Donner 7465* (AD, CANB, HO, NSW); just S of Vokes Hill Junction towards Cook on the Cook to Vokes Hill Junction rd, Great Victoria Desert, 8 July 1999, *D. Nicolle 2640 & J. Connors* (AD, CANB); Great Victoria Desert, 105.6 km N of the Oak Valley turnoff on the Cook to Vokes Hill rd, 8 July 1999, *J.R. Connors 929 & D. Nicolle* (CANB, NSW); south of Vokes Hill on tk to Cook, 15 Sep. 1995, *D. Nicolle 1514* (AD); 0.2 km NE of Waldana Well, 231.5 km N of Cook, 28 Aug. 1986, *M.I.H. Brooker 9426* (CANB); Watson to Maralinga rd, 14 Sep. 1995, *D. Nicolle 1492* (AD); Transline access tk, E of Ooldea, 24 Apr. 1998, *D. Nicolle 2317* (AD, PERTH); sand dunes in lake complex S of Lake Bring c. 25 miles NE of Barton and c. 100 miles W of Commonwealth Hill Homestead, 15 Dec. 1965, *D. Symon 3408* (AD, CANB, NSW); c. 16 km N from Eyre Hwy towards Yumbarra C.P., 5 July 1999, *J.R. Connors 908 & D. Nicolle* (CANB, NSW, PERTH); Googs tk, between Tarcoola and Ceduna, 22 July 1995, *D. Nicolle 1401* (AD); c. 15 km S of Tarcoola, which is on Transcontinental Railway, 1 Oct. 1971, *B. Lay 540* (CANB); tk between Lake Everard Station and Googs Lake, 30 Mar. 2011, *D. Nicolle 5941 & M.E. French* (PERTH); N of Wudinna on Bartley Rd, 28 Mar. 2011, *D. Nicolle 5926 & M.E. French* (PERTH); Skull Camp Tanks Rd, S of Moonaree Homestead, 23 Nov. 2020, *D. Nicolle 7959* (AD).

12. *Eucalyptus salicola* Brooker

Nuytsia 6(3): 329, Figs 1, 2b, 3b (1988). — **Holotype:** 14.6 km east of Kulja Central road on Mollerin North road, 24 Jan. 1984, *M.I.H. Brooker 8433 & S.D. Hopper* (PERTH1394517). **Isotypes:** CANB434630; MEL0687508; NSW350296.

Tree 6–20 m tall; lignotuber absent, obligate seeder (Nicolle 2006). *Bark* smooth throughout, reddish-orange to grey over yellow-cream to white, sometimes slightly powdery, decorticating annually in strips. *Branchlets* non-pruinose. *Seedling leaves* opposite for 18+ pairs, nodes 6–18 mm apart, sessile, cordate or orbicular to ovate, 5–20 mm long × 3–15 mm wide, length:width ratio typically 1–1.3:1, somewhat discolorous, dull, grey-green to grey, pruinose. *Coppice leaves* similar but typically larger, more spaced and eventually becoming disjunct. *Mature crown* composed entirely of adult leaves. *Adult leaves* with petioles 5–15 mm long, lamina lanceolate to narrow-lanceolate (rarely linear), 40–100 mm long × 3.5–12 mm wide, length:width ratio typically 7–12:1, glossy to very glossy, green to light green, non-pruinose; tertiary venation moderate to dense; oil glands numerous, connected to vein network (intersectional oil glands). *Inflorescences* 7–11-flowered; peduncles terete to angular, 4–10 mm long; pedicels 1–3.5 mm long. *Flower buds* ovoid to diamond-shaped, 4.5–8 mm long × 2–3 mm diam.; opercula bluntly conical to beaked, 2.5–4 mm long, length:width ratio typically 1–1.5:1. *Fruits* cupular, 3–5 mm long × 2.5–5 mm diam.; disc level to descending; valves 3 or 4, at rim level or below. **Fig. 26.**

Diagnostic characters. Distinguished within *E.* ser. *Porantherae* by the following combination of characters: Non-lignotuberous tree. Bark smooth and shedding throughout. Branchlets non-pruinose. Seedling leaves opposite, moderately-spaced, cordate or orbicular to ovate (length:width ratio 1–1.3:1), greyish, pruinose (Fig. 27). Adult leaves usually lanceolate to narrow lanceolate (length:width ratio 7.5–11:1), glossy to very glossy and green at all stages. Pedicels distinct. Opercula bluntly conical to slightly beaked. Fruits cupular.

Illustrations. M.I.H. Brooker & D.A. Kleinig, *Field Guide Eucalypts* 2: 306 (1990); 2nd edn, 2: 306 (2001); 3rd edn, 2: 279 (2016); A.V. Slee *et al.*, *EUCLID Eucalypts of Australia* CD ROM, *Eucalyptus salicola* (2006); M.E. French, *Eucalypts W. Austral. Wheatbelt* 262, 263 (2012).

Distribution and habitat. Endemic to W.A., where it is widespread but scattered from Lake Moore and Lake De Courcy south-eastwards to south of Balladonia (Fig. 9). It is restricted to the margins of ephemeral salt lakes and associated saline drainage lines and flats, or near claypans and other poorly-drained flat areas, in variously-coloured calcareous sands, loams and clays. It typically forms open woodland or mixed mallee woodland, sometimes in pure stands. Associated eucalypts include *Eucalyptus alipes*, *E. comitae-vallis*, *E. cylindrocarpa*, *E. delicata*, *E. eremophila*, *E. exigua*, *E. flocktoniae* subsp. *hebes*, *E. fraseri* subsp. *fraseri*, *E. lesouefii*, *E. loxophleba* subspp. *lissophloia* and *supralaevis*, *E. melanoxylon*, *E. myriadena*, *E. ovularis*, *E. platycorys*, *E. quadrans*, *E. salubris*, *E. tenera*, *E. virella*, *E. vittata* and *E. yilgarnensis*.

Conservation status. Globally listed as 'Near Threatened' on the IUCN Red List of Threatened Species (IUCN 2020). Considering its known distribution, life cycle (an obligate seeder), and threats (particularly increasing fire frequency), we believe that an IUCN Red List category of 'Vulnerable' is more appropriate.

Not a listed taxon under Conservation Codes for Western Australian Flora (Smith & Jones 2018). Recorded from various reserves including Dundas, Lake Campion, Lake Hurlstone, and Yarding nature reserves.

Fig. 26. *Eucalyptus salicola*, approximately 12 months post wildfire. **A** habit and habitat, indicating mature trees killed by fire; **B** lower trunks, lacking a lignotuber and lacking epicormic regrowth; **C** seedling regeneration (all at *D. Nicolle 7995 & M.E. French*, W of Parmango Rd, S of Balladonia, W.A.).

Common names. Salt Gum (Brooker & Kleinig 1990; Slee *et al.* 2006; French 2012).

Notes. *Eucalyptus salicola* is a tree which usually lacks a lignotuber and is killed by fire (i.e. is an obligate seeder). It is one of only two non-resprouting tree taxa in *E.* ser. *Porantherae*, the other being *E. kumarlensis*, which is a much more restricted species from the Kumarl – Lort River area. The habitat, habit and adult morphology of *E. salicola* and *E. kumarlensis* are very similar, and the two species are only reliably distinguished by their seedling morphology. Intergrades between the two species have been recorded to the north of the distribution of *E. kumarlensis*, south of Norseman (e.g. *Slee 4207*).

Fig. 27. *Eucalyptus salicola* seedlings. **A** F1 of *D. Nicolle 3882 & M.E. French*, S of Dundas cross roads on the Fraser Range to Mt Ridley track, W.A.; **B** F1 of *M.E. French 2697*, Holt Rock Rd North, W.A.; **C** F1 of *M.E. French 2730*, Victoria Rock Rd, N of Lake Johnston, W.A.; **D** F1 of *M.E. French 3259*, between old Hyden track and Cave Hill to Higginsville track, W.A.; **E** F1 of *M.E. French 3277*, edge of Lake Cowan, Norseman, W.A.

The seedling morphology of *E. salicola* suggests that it is most closely related to the mallee species *E. ecdysiastes* and *E. horistes*. *Eucalyptus salicola* is easily distinguished from both of these species in the field by its tree habit. Seedlings of *E. salicola* also tend to have smaller leaves than those of both *E. ecdysiastes* and *E. horistes*. Adult herbarium material of *E. salicola* can be indistinguishable from *E. ecdysiastes* and *E. horistes*. Large, long-unburnt mallees of *E. ecdysiastes* can be difficult to distinguish from *E. salicola* in the field unless seedlings are available.

A population of trees from east of Disappointment Rock on the Hyden-Norseman Road has some individuals that regenerate by vegetative shoots from the base of the plant following fire, suggesting the presence of a lignotuber. It may be that *E. salicola* is variable with respect to forming a lignotuber, and as such is variable in response to its regeneration strategy following wildfire. Similar variation in regeneration strategy has been observed in the distantly related Western Australian species *E. capillosa* Brooker & Hopper and *E. flavida* Brooker & Hopper of *E.* ser. *Levispermae* Maiden.

Selected specimens

WESTERN AUSTRALIA (west to east). Lake De Courcy, NW of Kalannie, 11 Sep. 2015, *M.E. French 2792* (PERTH); Baandee, on Great Eastern Hwy, 30 Sep. 2000, *D. Nicolle 3457 & M.E. French* (PERTH); Bimbijy Station, SE of Paynes Find, 2 Oct. 2000, *D. Nicolle 3493 & M.E. French* (CANB, PERTH); Holt Rock Rd North, 29 July 2014, *M.E. French 2697* (PERTH); Koolyanobbing-Southern Cross Rd, margin of Lake Deborah East, 3 May 2015, *D. Nicolle 7007 & M.E. French* (PERTH); Great Eastern Hwy, junction of tk and hwy c. 21 km W of Dedari Pumping Station tk, c. 66 km W of Coolgardie Post Office, c. 12 km along tk to salt lake, S of Woolgangie (water pipeline), 7 Oct. 1998, *B. Archer 1169* (CANB, MEL, PERTH); c. 80 km W of Coolgardie-Norseman rd on Hyden tk, 7 Nov. 1983, *M.I.H. Brooker 8354* (CANB, PERTH); Victoria Rock Rd, N of Lake Johnston, 26 Sep. 2014, *M.E. French 2730* (PERTH); on NE tk ex Old Hyden Tk to Cave Hill-Higginsville tk, 8 Dec. 2019, *M.E. French 3259* (PERTH); Mundale tk, south of Cave Hill-Higginsville tk, 8 Dec. 2019, *M.E. French 3263* (PERTH); Picnic Lake tk, SW of Norseman, 9 Dec. 2019, *M.E. French 3266* (PERTH); S of Norseman on Norseman-Esperance Hwy, 10 Dec. 2019, *M.E. French 3275* (PERTH); c. 4 km N of Norseman BP, prior to causeway on Coolgardie-Esperance Hwy, 10 Dec. 2019, *M.E. French 3276* (PERTH); Norseman town edge of Lake Cowan on rd to Hyden (road across lake), 10 Dec. 2019, *M.E. French 3277* (PERTH); rd to Dundas Rocks, S of Norseman, 7 Apr. 1985, *M.I.H. Brooker 8903* (CANB, PERTH); c. 37 km S of Dundas cross rds on the Fraser Range-Mt Ridley tk, 18 July 2001, *D. Nicolle 3882 & M.E. French* (AD, CANB); c. 25 km from Deralinya Homestead at Parmango Rd on tk running NW, 3 Mar. 2003, *D. Nicolle 4562 & M.E. French* (AD, CANB); W of Parmango Rd on track heading due W to northern end of Mt Ney tk, 17 Jan. 2021, *D. Nicolle 7995 & M.E. French* (PERTH).

13. *Eucalyptus ecdysiastes* K.D.Hill ex D.Nicolle & M.E.French, *sp. nov.*

Holotypus: Western Australia, 19.9 km S of Coolgardie on Burra Rock Rd, 12 Nov. 1985, *M.I.H. Brooker 9074* (PERTH01379488). **Isotypus:** CANB430651; MEL0680043; NSW349878.

Eucalyptus hypochlamydea subsp. 'smooth bark': Brooker & Kleinig, *Field Guide Eucalypts* 2: 304 (1990), *Ed. 2*, 2: 304 (2002).

Eucalyptus sp. Southern smooth (*D. Nicolle & M. French DN 6916*): Western Australian Herbarium, *FloraBase* https://florabase.dpaw.wa.gov.au (1998–).

Eucalyptus sp. Great Victoria Desert (*D. Nicolle & M. French DN 3877*), *p.p. min.*: D.Nicolle *et al.*, *Nuytsia* 22(3): 103 (2012).

Eucalyptus horistes subsp. 'smooth bark': Brooker & Kleinig, *Field Guide Eucalypts Ed. 3*, 2: 277 (2016).

This species has previously been recognised under the designation *Eucalyptus* 'ecdysiastes' (Hill 2004 ms), but a name was never formally published.

Mallee to 11 m tall, sometimes reaching tree-like proportions when long-unburnt; lignotuber present, lignotuber resprouter (Nicolle 2006). *Bark* smooth throughout, decorticating annually in strips, sometimes colourful, grey over yellow-orange to powdery white. *Branchlets* non-pruinose. *Seedling leaves* opposite for numerous pairs, nodes (5–) 8–20 (–28) mm apart, sessile, cordate or orbicular to ovate, 7–25 mm long × 6–20 mm wide, length:width ratio typically 1–1.8:1, slightly discolorous, dull, grey-green to grey, pruinose. *Coppice leaves* similar but typically larger and more spaced. *Mature crown* composed entirely of adult leaves. *Adult leaves* with petioles 4–11 mm long, lamina narrow-lanceolate (to lanceolate), 40–95 mm long × 4–12 (–14) mm wide, length:width ratio typically 6–12:1, glossy to very glossy, green to light green, non-pruinose; tertiary venation dense; oil glands numerous, connected to vein network (intersectional oil glands). *Inflorescences* 7–11-flowered; peduncles terete to angular, 4–11 mm long; pedicels 1–6 mm long. *Flower buds* ovoid to fusiform or diamond-shaped, 6–9 mm long × 2.5–3.5 mm diam.; opercula conical to beaked, 3–5 mm long, length:width ratio typically 1–1.6:1. *Fruits* truncate-globose to cupular to shortly barrel-shaped, 3–5 mm long × 3–5 mm diam.; disc descending; valves 3 (4), at rim level or below.

Diagnostic characters. Distinguished within *E.* ser. *Porantherae* by the following combination of characters: Lignotuberous mallee. Bark smooth and shedding throughout. Branchlets non-pruinose. Seedling leaves opposite, moderate to well-spaced, cordate or orbicular to ovate (length:width ratio 1–1.8:1), greyish, pruinose (Fig. 28). Adult leaves narrow-lanceolate, glossy and green at all ages. Pedicels distinct. Opercula conical to beaked. Fruits truncate-globose to cupular to shortly barrel-shaped.

Illustrations. M.I.H. Brooker & D.A. Kleinig, *Field Guide Eucalypts* 2: 304 (1990); 2nd edn, 2: 304 (2001); 3rd edn, 2: 277 (2016).

Distribution and habitat. Endemic to W.A., where it is widespread but scattered through the wheatbelt and southern goldfields, from Alexander Morrison National Park, Moora and York eastwards to Kalgoorlie and to south of the Fraser Range, and extending inland to the Lake Minigwal, Lake Rason and Yeo Lake areas, and south to near the coast at Fitzgerald River (Fig. 29). It grows on level or slightly undulating topography, often in shallow broad depressions or on slight rises near salt lakes, in variously coloured sands and loams, forming mallee. Associated eucalypts include *Eucalyptus arachnaea* subsp. *arachnaea*, *E. armillata*, *E. aspratilis*, *E. conglobata* subsp. *perata*, *E. cylindrocarpa*, *E. dissimulata*, *E. ecostata*, *E. flocktoniae* subsp. *flocktoniae*, *E. incrassata s.lat.*, *E. leptopoda* subsp. *leptopoda*, *E. loxophleba* subsp. *loxophleba*, *E. moderata*, *E. neutra*, *E. obtusiflora*, *E. platycorys*, *E. salmonophloia*, *E. sheathiana*, *E. tenera*, *E. transcontinentalis*, *E. vittata*, *E. uncinata* subsp. *uncinata* and *E. urna*.

Conservation status. Not yet assessed under the IUCN Red List of Threatened Species (IUCN 2020). Considering its known distribution, life cycle, and threats, we believe that an IUCN Red List category of 'Near Threatened' is appropriate for the species.

Not a listed taxon under Conservation Codes for Western Australian Flora (Smith & Jones 2018). Recorded from Dundas and Yeo Lake nature reserves and Fitzgerald River and Alexander Morrison national parks.

Etymology. From the Greek *ecdysisastes* (one who escapes from), referring to the smooth, shedding bark, which distinguishes the species from the related *E. horistes*, with which it was previously included.

Common names. None known.

Notes. *Eucalyptus ecdysiastes* was previously included in *E. horistes* (Brooker & Kleinig 2001, 2016; Slee *et al.* 2015), and the two species are very similar in their habit, seedling leaves and reproductive morphology. We regard *E. ecdysiastes* to have an equally close relationship to *E. horistes*, *E. lunata* and *E. salicola*. *Eucalyptus horistes* differs from *E. ecdysiastes* most notably in the non-shedding, rough bark on its lower trunks. It also tends to have broader adult leaves than *E. ecdysiastes*, although with much overlap in size. The distribution of *E. ecdysiastes* is generally to the south-west of that of *E. horistes*. Intergrades between the two species have been recorded where their distributions adjoin, near Miling, near Westonia, north-west of Kalgoorlie, and north of Zanthus.

Eucalyptus lunata differs from *E. ecdysiastes* in its narrower adult leaves and smaller, more crowded seedling leaves. Intergrades between *E. ecdysiastes* and *E. lunata* occur in the Lake Grace – Newdegate area.

Eucalyptus salicola differs from *E. ecdysiastes* in its non-lignotuberous tree habit and its variably smaller seedling leaves. Populations of *E. ecdysiastes* in the Lake Minigwal to Lake Rason area in the south-western Great Victoria Desert have previously been included in *E. salicola* (Slee *et al.* 2015; Brooker & Kleinig 2016), possibly because of the presence of old, long-unburnt individuals that have become tree-like in stature. However, such tree-like individuals are nonetheless lignotuberous, as evidenced by their lignotuberous regrowth following extensive wildfires in the region in summer 2019/20.

The distribution of *E. ecdysiastes* is partly sympatric with a number of other species of *E.* ser. *Porantherae*, such as *E. salicola*, *E. olivina* and *E. rigidula* (all three of which are widespread throughout much of the distribution of *E. ecdysiastes*), *E. lunata* and *E. dissimulata* (both in the south-west of the distribution of *E. ecdysiastes*) and *E. horistes* (in the Bullfinch – Koolyanobbing area), However, except for *E. dissimulata*, *E. ecdysiastes* is not known to grow in association with any of these species, apparently being finely ecologically separated.

Selected specimens

WESTERN AUSTRALIA (west to east). Far eastern Darling Ra. Forest area, W of Beverley, E of Gunapin, 12 July 2015, *M.E. French 2789* (PERTH); c. 3 km S of Cadoux towards Koorda, 19 Apr. 1998, *D. Nicolle 2227* (PERTH); Wyola South Rd, E of Cunderdin, 1 Jan. 2015, *M.E. French 2762* (PERTH); Badjaling North Rd, NE of Quairading, 4 Mar. 2015, *M.E. French 2767* (PERTH); Finey Rd, SE of Tammin, 26 Apr. 2015, *D. Nicolle 6916 & M.E. French* (PERTH); E from Tincurrin North Rd, N of Tincurrin school, 29 Apr. 1999, *A.V. Slee 4088* (CANB, PERTH); Kulin-Kondinin Rd, 20 Feb. 2013, *M.E. French 2600* (PERTH); corner of South Fence Rd and Martens Rd, 8 Jan. 2007, *D. Nicolle 5063 & M.E. French* (AD, CANB, PERTH); Bullfinch-Turkey Hill Rd, NE of Bullfinch, 2 Dec. 2016, *M.E. French 2907* (PERTH); corner of Marvel Loch Rd and Patroni Rd, W of Marvel Loch, 24 Nov. 2013, *D. Nicolle 6691 & M.E. French* (PERTH); Fitzgerald River tk, Fitzgerald River N.P., 23 Mar. 2010, *D. Nicolle 5513 & M.E. French* (CANB, MEL, PERTH); c. 1 km N of Great Eastern Hwy on tk to Weowanie Rock (at Yellowdine), 2 Nov. 2000, *B.J. Lepschi & L.A. Craven 4492* (CANB, PERTH); Coolgardie North Rd, c. 25 km N of Coolgardie, 2 May 2015, *D. Nicolle 6995 & M.E. French* (PERTH); Lake King-Kumarl-Norseman Rd, 14 July 2019, *M.E. French 3186* (PERTH); Great Eastern Hwy, SW of Coolgardie, 12 Sep. 2014, *M.E. French 2715* (PERTH); Cave Hill, Widgiemooltha Rd, just W of Widgiemooltha, 26 Sep. 2014, *M.E. French 2733* (PERTH); Widgiemooltha to Cave Hill Rd, 1 May 2015, *D. Nicolle 6994 & M.E. French* (PERTH); 50 Mile Rocks, SW of Higginsville, NW of Norseman, 31 Oct. 2015, *M.E. French 2826* (PERTH); c. 31 km S of Dundas N.R. boundary gate with Southern Hills Station on the Fraser Range-Mt Ridley tk, 18 July 2001, *D. Nicolle 3877 & M.E. French* (AD, CANB, PERTH); c. 8 km E from Fraser Range to Mt Ridley tk on Optus fibre optic cable tk, 2 Mar. 2003, *D. Nicolle 4546 & M.E. French* (AD); S side of Lake Minigwal, 30 Sep. 1993, *D. Nicolle 527* (AD); between Balpe Lakes and Lake Minigwal, Great Victoria Desert, 18 July 1999, *D. Nicolle*

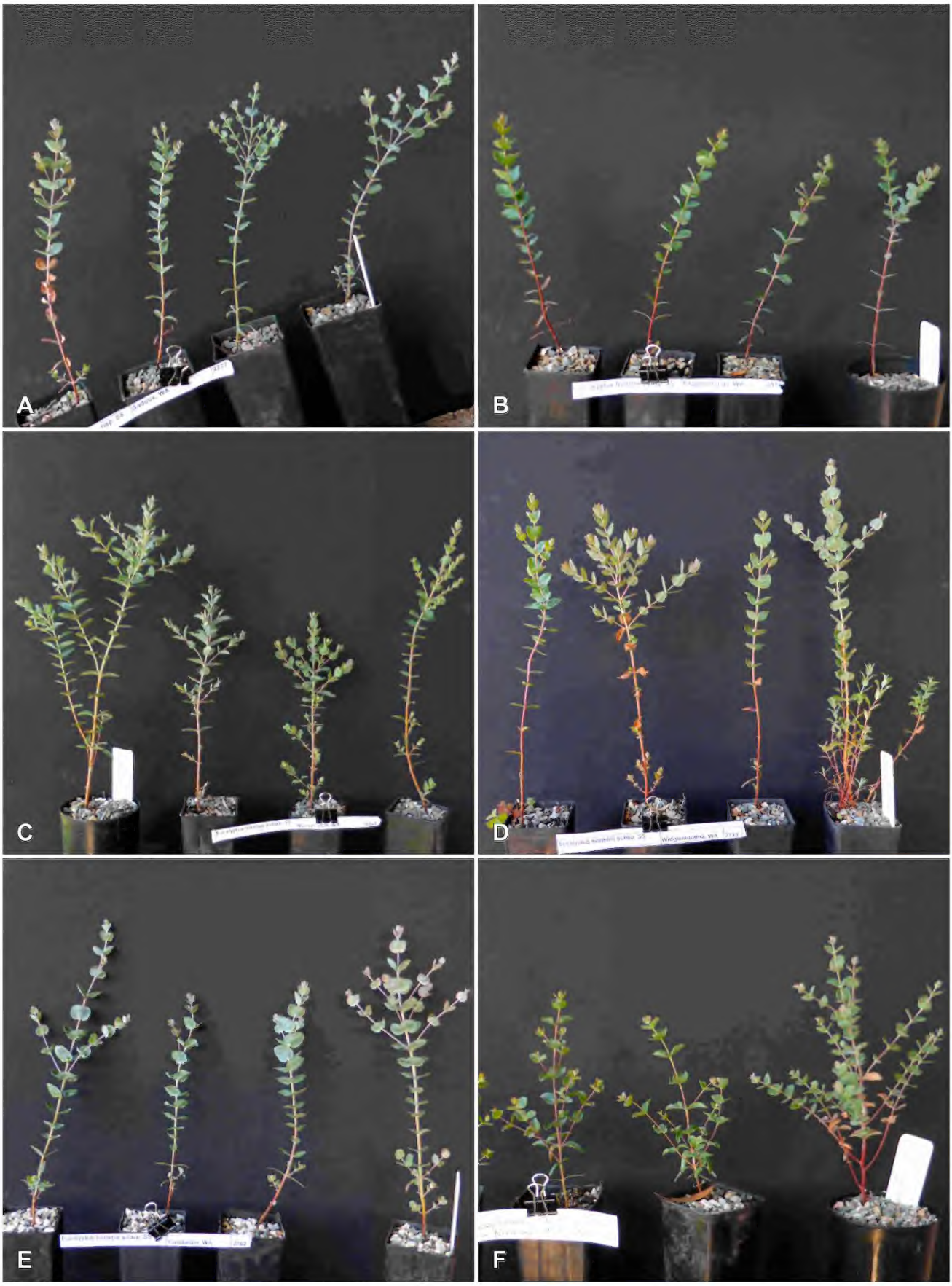

Fig. 28. *Eucalyptus ecdysiastes* seedlings. **A** F1 of *D. Nicolle 2227*, S of Cadoux towards Koorda, W.A.; **B** F1 of *D. Nicolle 5513 & M.E. French*, Fitzgerald River track, Fitzgerald River N.P., W.A.; **C** F1 of *D. Nicolle 6691 & M.E. French*, corner of Marvel Loch Rd and Patroni Rd, W of Marvel Loch, W.A.; **D** F1 of *M.E. French 2733*, Cave Hill, W of Widgiemooltha, W.A.; **E** – F1 of *M.E. French 2762*, Wyola South Rd, E of Cunderdin, W.A.; **F** F1 of *M.E. French 2826*, Fifty Mile Rocks, SW of Higginsville, W.A.

2730 & J. Connors (AD); PNC Baseline Rd, 28 Apr. 2015, *D. Nicolle 6945 & M.E. French* (PERTH); Great Victoria Desert, Yeo Lake N.R., S margin of Yeo Lake, 2 Oct. 2013, *M.D. Crisp 11451* (CANB, PERTH); S of Lake Rason, c. 152 km NW of airstrip, Great Victoria Desert, 13 May 1984, *M.I.H. Brooker 8578* (CANB, PERTH); 7.1 km from Tropicana Mine haul rd on tk to Lake Rason, 27 Oct. 2019, *D. Nicolle 7814 & M.E. French* (PERTH).

14. *Eucalyptus horistes* L.A.S.Johnson & K.D.Hill

Fl. Australia 19: 254–255, 509, Fig. 77I–J, Map 284 (27 June 1988). — **Holotype:** 15.9 km N of Binnu on Highway 1, W.A., 27°54'S, 114°42'E, 27 Oct. 1983, *K. Hill 389, L. Johnson, D. Blaxell & I. Brooker* (NSW344952). **Isotypes:** AD99322033; CANB446018 [ex FRI]; MEL0708786; PERTH.

Eucalyptus hypochlamydea Brooker, *Nuytsia* 6(3): 328, Figs 1, 2a, 3a (23 Dec. 1988). — **Holotype:** 13.8 km E of Mullewa towards Pindar, 24 Jan. 1984, *M.I.H. Brooker 8412* (PERTH1390376). **Isotypes:** CANB412801; MEL1610707; NSW349691.

Mallee to 14 m tall, sometimes reaching tree-like proportions when long unburnt; lignotuber present, lignotuber resprouter (Nicolle 2006). *Bark* rough for 0.6–6 m, flaky-fibrous, grey, then smooth above, decorticating annually in strips, grey over orange-tan to cream. Small and young individuals sometimes completely smooth-barked. *Branchlets* non-pruinose. *Seedling leaves* opposite for 18+ pairs, nodes 6–70 mm apart, sessile, cordate or orbicular to ovate or broadly elliptical, 9–55 mm long × 6–35 mm wide, length:width ratio typically 1–1.6:1, slightly discolorous, dull, grey-green to grey, pruinose. *Coppice leaves* similar but typically larger and more spaced. *Mature crown* composed entirely of adult leaves. *Adult leaves* with petioles 5–15 mm long, lamina narrow-lanceolate to lanceolate, 40–90 mm long × 5–16 mm wide, length:width ratio typically 5–9.5:1, glossy to very glossy, green to light green, non-pruinose; tertiary venation dense; oil glands numerous, connected to vein network (intersectional oil glands). *Inflorescences* 7–13-flowered; peduncles terete to angular, 3–10 mm long; pedicels 1–4 mm long. *Flower buds* ovoid to fusiform or diamond-shaped, 5.5–9 mm long × 2–4 mm diam.; opercula conical to slightly beaked, 3–5 mm long, length:width ratio typically 1.2–1.8:1. *Fruits* truncate-globose to cupular to shortly barrel-shaped, 3–6 mm long × 3.5–5.5 mm diam.; disc slight descending to steeply descending; valves 3 (4), at or below rim level. **Fig. 30.**

Diagnostic characters. Distinguished within *E.* ser. *Porantherae* by the following combination of characters: Lignotuberous mallee. Bark persistent (non-shedding) on lower trunks. Branchlets non-pruinose. Seedling leaves opposite, moderately to well-spaced, cordate or orbicular to ovate or broadly elliptical, greyish, pruinose (Fig. 31). Adult leaves narrow-lanceolate to lanceolate, glossy and green at all ages. Pedicels distinct. Opercula conical to slightly beaked. Fruits truncate-globose to cupular to shortly barrel-shaped.

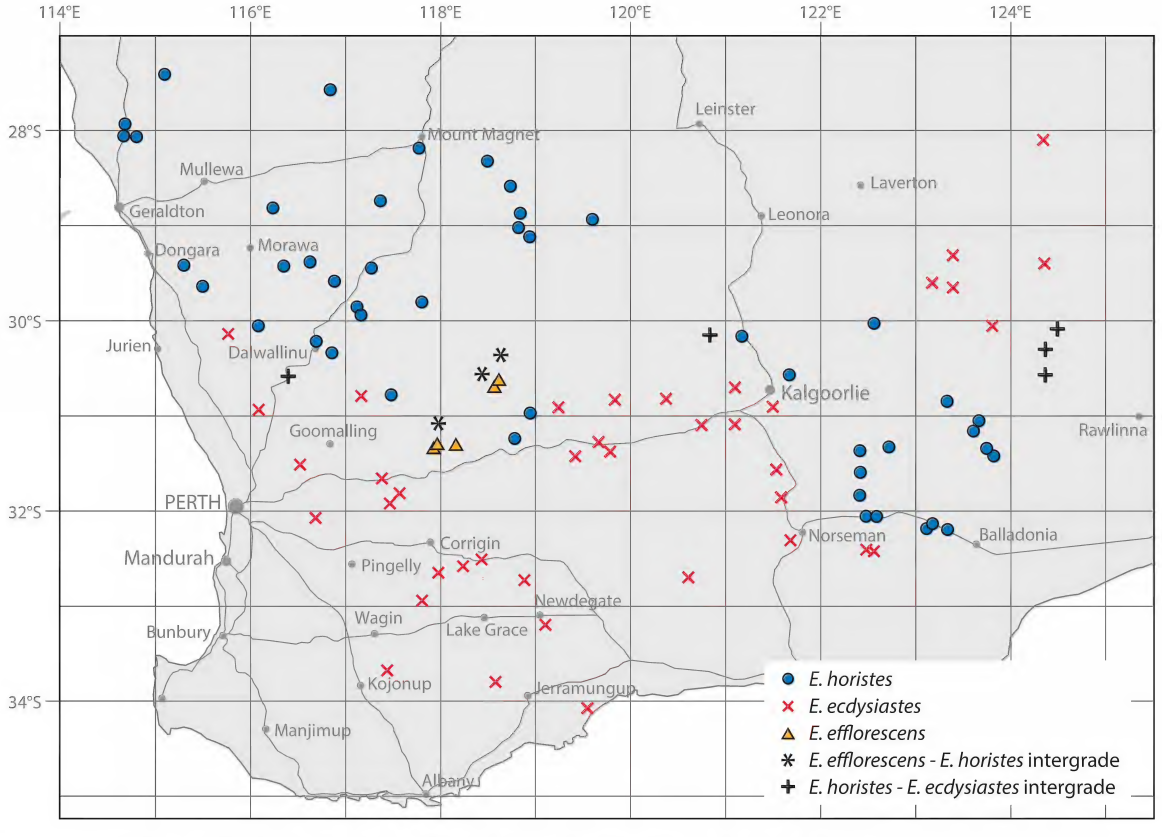

Fig. 29. Distribution of *Eucalyptus ecdysiastes*, *E. horistes* and *E. efflorescens* in Western Australia.

Fig. 30. *Eucalyptus horistes*. **A** habitat and habit (*D. Nicolle 5555 & M.E. French*, S of Coorow, W.A.); **B** coppice from lignotuber (*D. Nicolle 8019 & M.E. French*, Eyre Hwy E of Norseman, W.A.); **C** coppice from lignotuber (*D. Nicolle 8022 & M.E. French*, Balladonia to Zanthus track, W.A.).

Illustrations. M.I.H. Brooker & D.A. Kleinig, *Field Guide Eucalypts* 2: 303 (1990); 2nd edn, 2: 303 (2001); 3rd edn, 2: 276 (2016); *Eucalypts W. Austral. - S.W. Coast & Ranges* 219 (2019), habit images and seedling painting.

Distribution and habitat. Endemic to W.A., where it is the most widespread species in the series, with a linear range of over 1,000 km, extending from Toolonga Nature Reserve in the north-west, south-east to near Balladonia roadhouse and the Zanthus area on the western edge of the Nullarbor Plain, and inland to Mount Magnet and the Sandstone area (Fig. 29). It grows on level or slightly undulating topography in a variety of substrates including red clay-loams on flats to pale-coloured sands on lunettes and sand dunes near salt lakes. It occurs as a component to open shrubland or mallee shrubland, sometimes with *Callitris* species or mulga. Associated eucalypts include *Eucalyptus comitae-vallis*, *E. cyclostoma*, *E. cylindrocarpa*, *E. effusa* subsp. *effusa*, *E. eremophila*, *E. ewartiana*, *E. grossa*, *E. histophylla*, *E. kingsmillii*, *E. kochii* subsp. *amaryssia*, *E. leptopoda* subsp. *arctata*, *E. loxophleba* subsp. *supralaevis*, *E. oleosa* subsp. *oleosa*, *E. pyriformis*, *E. rigidula* subspp. *clancularia*, *interior* and *rigidula*, *E. salubris*, *E. spreta*, *E. subangusta* subsp. *pusilla* and *E. transcontinentalis*.

Conservation status. Globally listed as 'Near Threatened' on the IUCN Red List of Threatened Species (IUCN

Fig. 31. *Eucalyptus horistes* seedlings. **A** F1 of *D. Nicolle 1169*, N of Binnu, W.A.; **B** F1 of *M.E. French 2169*, SE of Mingenew, W.A.; **C** F1 of *M.E. French 2752*, E of Perenjori, W.A.; **D** F1 of *D. Nicolle 2756 & J. Connors*, S of Mount Magnet, W.A.; **E** F1 of *D. Nicolle 3643 & M.E. French*, Eyre Hwy, E of Norseman, W.A.; **F** F1 of *D. Nicolle 3985 & M.E. French*, Woodline Hills, W.A.

2020). We believe this assessment overstates the level of threat to *E. horistes*, as it is widespread and common over a large area. Considering its known distribution, life cycle, and threats, we believe that an IUCN Red List category of 'Least Concern' is more appropriate.

Not a listed species under Conservation Codes for Western Australian Flora (Smith & Jones 2018). Recorded from Toolonga Nature Reserve.

Common names. Pointed-bud Mallee (French 2012; French & Nicolle 2019), Wongamine Mallee (French 2012; Brooker & Kleinig 2016).

Notes. A widespread species, closely related to the following broadly allopatric species: *E. ecdysiastes* (occurring mainly to the south-west, but also to the north-east, of *E. horistes*), *E. omissa* (occurring to the east), *E. fruticosa* (occurring to the north and

north-west) and *E. efflorescens* (which geographically replaces *E. horistes* in the Trayning to Bonnie Rock area). *Eucalyptus horistes* is also closely related to the partly sympatric, but ecologically separated, *E. salicola*, which differs most notably in its tree habit and completely smooth, shedding bark.

Eucalyptus ecdysiastes has a very similar habit, seedling leaves and reproductive morphology to *E. horistes*, and differs from the latter most notably in the completely shedding, smooth bark. It also tends to have narrower adult leaves than in *E. horistes*. The two species intergrade where their distributions adjoin in the west, such as near Miling, Westonia, Ora Banda and north of Zanthus.

There is a large east-west disjunction in the distribution of *E. horistes*, with the taxon being apparently absent from the Mount Jackson to Goongarrie area, where it is geographically replaced by *E. formanii*. *Eucalyptus formanii* subsp. *formanii* is easily distinguished from *E. horistes* by its much narrower leaves at all stages, however, specimens of the broader-leaved *E. formanii* subsp. *circulata* cannot be distinguished from *E. horistes* unless juvenile growth is present. The juvenile morphology of *E. formanii* and *E. horistes* is vastly different, and juvenile growth can often be found as coppice from the lignotuber or lower trunks in the field.

The juvenile leaves of *E. horistes* are sometimes conspicuous in the field, either as seedlings or as coppice growth from the lignotuber or lower trunks of damaged plants. There is some geographical variation in *E. horistes*, with eastern populations tending to have larger and more widely spaced juvenile and intermediate leaves. Eastern populations also tend to have slightly larger (longer and broader) adult leaves than western populations, but these differences are weak, with almost complete overlap of adult leaf measurements. The manuscript name *Eucalyptus* 'stanbergiana' was applied to these eastern populations by Ken Hill (Peter Wilson, pers. comm.), but the name was never formally published. The name honours Leonie Clare Stanberg (1964–), a research assistant and technical officer at the National Herbarium of New South Wales from 1987 until 2016, who worked closely with Ken Hill revising eucalypt taxonomy in the 1990s and 2000s. One of us (MF) also considered that the eastern populations were distinct enough to warrant their subspecific recognition (i.e. as *E. horistes* subsp. 'stanbergiana'). However, inter-population variability and overlap in the size and spacing of the juvenile leaves and the size of the adult leaves makes any differentiating characters very difficult to quantify. We here take a conservative taxonomic approach by refraining from describing subspecies within *E. horistes*, pending further study.

A population of mallees about 50 km west-south-west of Balladonia roadhouse (*D. Nicolle 4553 & M.E. French*) has many similarities to *E. horistes* in both seedling and adult material, but is atypical, differing especially in its more elliptical, greener, non-pruinose juvenile (seedling and coppice) leaves. Further field research is required to ascertain its identity and relationships.

Selected specimens

WESTERN AUSTRALIA (west to east). Toolonga N.R., E of Nerren Nerren Station, SE of Shark Bay, 2 May 2014, *M.E. French 2684* (PERTH); North West Coastal Hwy, N of Binnu, 27 Nov. 1994, *D. Nicolle 1169* (AD); E of Binnu, 31 Oct 1984, *M.I.H. Brooker 8726* (CANB, PERTH); private property, NE of Eneabba, due W of Carnamah, 28 July 2013, *M.E. French 2630* (PERTH); Solomon Rd, E of Perenjori, 5 Dec. 2014, *M.E. French 2752* (PERTH); 12.1 km S on rd from Wubin-Paynes Find Rd to Kalannie, 10 Dec. 2005, *A.V. Slee 4349* (CANB); c. 28 km W of the Great Northern Hwy towards Wanarra Homestead and Perenjori (turnoff is near Mt Gibson), 21 Oct. 1978, *L.D. Pryor & J.D. Briggs 128* (CANB, PERTH); c. 67 km by rd S of Mount Magnet to Sandstone rd towards Youanmi, 22 July 1999, *D. Nicolle 2756 & J. Connors* (AD, PERTH); c. 9 km NE of Westonia on Boodarockin Rd, 0.7 km S of Sandford Rock Res., 18 May 1999, *A.V. Slee 4154* (AD, CANB, PERTH); near Browns Soak, S of Youanmi, 14 May 2017, *D. Nicolle 7311 & M.E. French* (PERTH); 36.9 km S of Youanmi on Menzies Rd, 3 Jan. 2021, *M.E. French 3511* (PERTH); Karolin Rock, W of Bullfinch, 20 Oct. 2014, *M.E. French 2739* (PERTH); on Youanmi Menzies Rd, N of Lake Barlee HS, 3 Jan. 2021, *M.E. French 3512* (PERTH); S of Goongarrie on Goldfields Hwy, 2 Jan. 2021, *M.E. French 3491* (PERTH); Pinjin Rd, NE Kalgoorlie, 14 Feb. 2020, *M.E. French 3293* (PERTH); SW of Karonie, due E of Kambalda, 30 Nov. 2020, *M.E. French 3468* (PERTH); c. 30 km N of Eyre Hwy on Heartbreak Ridge tk, S of Woodline Hills, 1 May 2015, *D. Nicolle 6985 & M.E. French* (PERTH); E edge of salt lake crossing on tk, 1 May 2015, *D. Nicolle 6992 & M.E. French* (PERTH); between Norseman and the Fraser Ra. on the Norseman-Balladonia hwy, 9 Nov. 2000, *D. Nicolle 3643 & M.E. French* (CANB, PERTH); adjacent to new haul rd, Edjudina Station South, W of Pinjin-Yarri Rd, 28 Dec. 2018, *M.E. French 3092* (PERTH); 86 km E of Norseman on Eyre Hwy, 13 Oct. 2005, *A.V. Slee 4255 & J.R. Connors* (CANB); SE of Karonie, N of Fraser Ra., 30 Nov. 2020, *M.E. French 3467* (PERTH); c. 20 km SW of Eyre Hwy on Harms Lake tk, 15 Jan. 2021, *D. Nicolle 7979 & M.E. French* (PERTH); c. 5 km SW of Eyre Hwy on Harms Lake tk, 15 Jan. 2021, *D. Nicolle 7976 & M.E. French* (PERTH); Coonana to Cundeelee tk, S of Ponton Creek, 30 Dec. 2018, *M.E. French 3100* (PERTH); Eyre Highway, between Balladonia and Fraser Ra., 30 Apr. 2015, *D. Nicolle 6974 & M.E. French* (PERTH); Balladonia-Zanthus tk, 20 Jan. 2021, *D. Nicolle 8024 & M.E. French* (PERTH); c. 42 km by road S of Transcontinental railway line near Zanthus towards Balladonia Roadhouse, 25 July 1999, *D. Nicolle 2790 & J. Connors* (AD); c. 42 km S of Zanthus towards Balladonia, 25 July 1999, *J.R. Connors 1066 & D. Nicolle* (PERTH, CANB); Balladonia-Zanthus tk, 20 Jan. 2021, *D. Nicolle 8022 & M.E. French* (PERTH).

15. *Eucalyptus efflorescens* L.A.S.Johnson & K.D.Hill ex D.Nicolle & M.E.French, ***sp. nov.***

Holotypus: Western Australia, north-west side of Elachbutting Hill, 1 Oct. 2000, *D. Nicolle 3486 & M.E. French* (PERTH05789168). **Isotypi:** AD; CANB626246.

Eucalyptus leptophylla var. *floribunda* Blakely, *Trans. & Proc. Roy. Soc. South Australia* 60: 155 (1936). — **Type citation:** "Mount Churchman, about 50 miles north-west from Knutsford, Elder Exploring Expedition, R. Helms, December 10 1891". **First-step lectotype:** "Mt Churchman, 50 miles [80 km] NW of Knutsford, W.A., 10 Dec. 1891, *R.Helms s.n.*" (NSW), *fide* Chippend., *Fl. Australia* 19: 282 (1988), as "holo". **Second-step lectotype (here designated):** Elder Exploring Expedition, Mt Churchman - 50 mls S.E., 10 Dec. 1891, *R. Helms s.n.* (NSW53408, annotated by Blakely). **Isolectotypes:** 20ft, granite formation, 50 miles SE Mt Churchman, 10 Dec. 1891, *R. Helms s.n.* (AD97448056 ex ADU); Mt Churchman - 50 mls SE, 10 Dec. 1891, *R. Helms s.n.* (AD97448061, ex ADU); 50 miles SE of Mt Churchman, W.A., 10 Dec. 1891, *R. Helms s.n.* (K000347533, ex NSW, annotated by Chippendale; US00409807, ex NSW); 50 miles NW from Knutsford, W.A., Dec. 1891, *R. Helms s.n.* (AD97448060, ex ADU; AD97448062, ex ADU; K000347530, annotated by Chippendale; MEL1607414; NSW349674, ex Mus. Appl. Arts & Sci.); Eucalyptus no 5, 20ft, granite formation, 50 miles S.E. from Mt Churchman = 50 miles N.W. from Knutsford, 10 Dec. 1891, *R. Helms s.n.* (AD96950121, annotated by Blakely); 50 miles NW of Knutsford, Mt Churchman - 50 mls S.E. [on two separate NSW labels], W.A., 10 Dec. 1891, *R. Helms s.n.* (CANB422171, [ex FRI?,] ex NSW, annotated by Blakely); c. 80 km NW from Knutsford, c. 80 km SE of Mt Churchman, 10 Dec. 1891, *R. Helms s.n.* (CANB422178, ex FRI, ex AD); near Knutsford, W.A., Dec 1891, *R. Helms s.n.* (K000347531, collector cited as "R.H.", ex Herb. Morrison, annotated by Chippendale; K000347532, ex Dept of Agric., W.A., annotated by Chippendale).

Eucalyptus sp. Mukinbudin (*D. Nicolle & M. French DN 3486*): D.Nicolle *et al.*, *Nuytsia* 22(3): 98 (2012).

Mallee to 10 m tall; lignotuber present, lignotuber resprouter (Nicolle 2006). *Bark* rough for 2–3 m, fibrous, grey, then smooth above, grey over tan, decorticating annually in strips. *Branchlets* often pruinose. *Seedling leaves* opposite for numerous pairs, nodes 6–18 mm apart, sessile, orbicular (to broadly ovate), 8–24 mm long × 9–22 mm wide, length:width ratio typically 1–1.1:1, slightly discolorous, dull, grey-green to grey, strongly pruinose. *Coppice leaves* similar but typically larger, more spaced and becoming petiolate. *Mature crown* composed of mixed juvenile and adult leaves or entirely of adult leaves. *Adult leaves* with petioles 5–12 mm long, lamina lanceolate to narrow-lanceolate, 35–75 mm long × 5–13 mm wide, length:width ratio typically 5–8:1, dull to slightly glossy, blue-green to dark green, sometimes pruinose when young; tertiary venation dense; tertiary venation very dense; oil glands numerous, connected to vein network (intersectional oil glands). *Inflorescences* 7–11-flowered; peduncles terete, 4–10 mm long; pedicels 1–5 mm long. *Flower buds fusiform*, 6–9 mm long × 2–3.5 mm diam.; opercula beaked, 4.5–5 mm long, length:width ratio typically 1.4–1.8:1. *Fruits* cupular to shortly barrel-shaped, 3–5 mm long × 3–4.5 mm diam.; disc level to descending; valves 3 or 4, around rim level.

Diagnostic characters. Distinguished within *E.* ser. *Porantherae* by the following combination of characters: Lignotuberous mallee. Bark persistent (non-shedding) on lower trunks. Branchlets often pruinose. Seedling leaves opposite, orbicular (length:width ratio 1–1.1:1), moderately-spaced, greyish, strongly pruinose (Fig. 32), juvenile leaves present in the mature canopy. Adult leaves lanceolate to narrow-lanceolate, dull to slightly

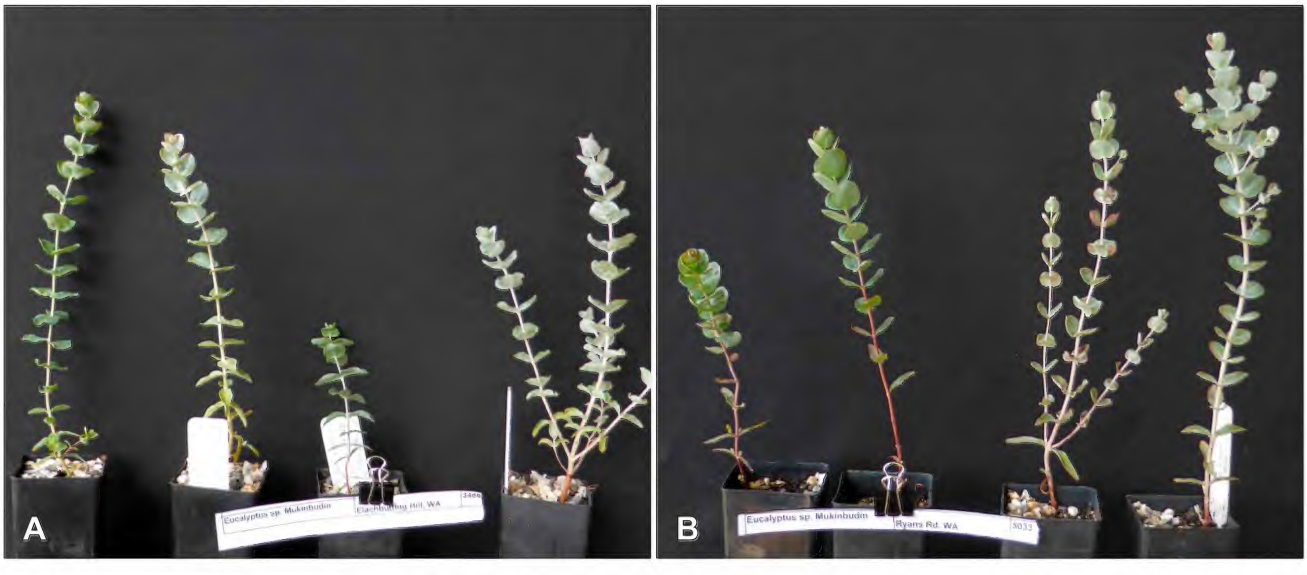

Fig. 32. *Eucalyptus efflorescens* seedlings. **A** F1 of *D. Nicolle 3486 & M.E. French*, NW side of Elachbutting Hill, W.A.; **B** F1 of *D. Nicolle 5033 & M.E. French*, corner of Ryans Rd and Baandee North Rd, W.A.

glossy. Pedicels distinct. Opercula conical to slightly beaked. Fruits cupular to shortly barrel-shaped.

Typification. The original material for *Eucalyptus leptophylla* var. *floribunda* was gathered by R. Helms on the 10 Dec. 1891 as part of the Elder Exploring Expedition. In the protologue, Blakely (1936) stated that the tree is "20ft high in granite formation" and cited "Mount Churchman, about 50 miles north-west from Knutsford". However, none of the specimens are labelled with this exact collecting location. The Helms specimens matching this taxon and date have locations including "Mt Churchman - 50 mls S.E.", "50 mls N.W. from Knutsford", "near Knutsford" and a combination of these (see types listed above).

The location of the 1891 Elder Exploring Expedition on and around the 10 Dec. is well documented by Lindsay (1893). On 7 Dec., the party departed Depot No. 4 near Golden Valley (Knutsford) and travelled via "Barcootin" [Barcooting Hill] to arrive at "Enuin" [presumably Ennuin, about 17 km north of Knutsford] on 9 Dec. On 10 Dec., the day the material of *E. leptophylla* var. *floribunda* was gathered, the party travelled from Ennuin to "Elijahputten" [presumably Elachbutting Hill]. On the next day, 11. Dec., the party camped at "Elijahputten or Elichaputten". The party did not arrive at what they supposed to be Mt Churchman until the 14th of December. However, it became soon clear to the Expedition that they never reached the mountain and that the real Mt Churchman must have been further west. Problems with specimens annotated as coming from Mt Churchman are well-known and it is often impossible to deduce the precise collecting location (R.M. Barker, pers. comm., July 2021).

A specimen at AD with an original collection label written by Helms, states "50 miles S.E. from Mt Churchman = 50 miles N.W. from Knutsford" (AD96950121), i.e. Helms equated the two locations, meaning that the specimen was collected about half way between Knutsford and the hill the Expedition supposed to be Mt Churchman. The annotation "20ft" and "granite formation" is only present on this original collecting label and not on later labels with the printed heading "Elder Exploring Expedition".

We believe that all of these specimens should be considered to be duplicates. They were almost certainly collected in the vicinity of Elachbutting Hill, approximately 100 km (62 miles) south-east of present-day Mt Churchman and 52 km (32 miles) directly north-west of Knutsford.

Mt Churchman is a large granite outcrop about 60 km north of Beacon. It is over 90 km north-west of the current known distribution of *E. efflorescens*, and approximately 150 km (95 miles) north-west of the long-abandoned township of Knutsford (also known as Golden Valley, and about 13 km north-west of Bullfinch). We have searched for the taxon at Mt Churchman and at nearby granite outcrops without success, and other earlier searches for the taxon at the "type locality" of Blakely (1936) by M.I.H. Brooker, S.D. Hopper, L.A.S. Johnson, D.F. Blaxell and K. Hill have also been unsuccessful (Brooker 1988).

Chippendale (1988) repeated in his *Flora of Australia* treatment the incorrect location given by Blakely (1936) and stated that the "holo" of *Eucalyptus leptophylla* var. *floribunda* is at NSW. This can be interpreted as an inadvertent lectotypification of the name. However, there are now two specimens of the Helms collection at that herbarium: NSW53408, annotated by Blakely, and NSW349674 from the Museum of Applied Arts & Sciences, the herbarium of which was transferred to NSW in 1979, but not incorporated into the collection until 1981 (P.G. Wilson, pers. comm., July 2021). It is not clear that Chippendale actually saw either of the NSW specimen, as he did not annotate any of them, in contrast to the four K type specimens, which all bear labels with his signature. He might have just assumed that there was a specimen in NSW herbarium, as the duplicate at CANB (where Chippendale worked) was ex NSW, where Blakely worked at the time of the publication.

The indication of "NSW" by Chippendale (1988) is here interpreted as a first-step lectotypification, which is limited above in a second step to the specimen annotated by Blakely. As explained, the other specimens are accepted as isolectypes, even though they are not all labelled with exacly the same location as the lectotype.

Illustrations. M.E. French, *Eucalypts W. Austral. Wheatbelt* 260, 261 (2012).

Distribution and habitat. Endemic to W.A., where it is restricted to a broad south-west to north-east band in the central wheatbelt, from North Baandee and Trayning north-eastwards to north-east of Bonnie Rock (Fig. 29). It grows in variously-coloured sandy-loam to granitic sand, often near the base of large granite outcrops (e.g. Yanneymooning Hill and Elachbutting Hill). It grows in mallee shrubland or mixed mallee-woodland with a variety of other eucalypts including *Eucalyptus comitae-vallis*, *E. leptopoda* subsp. *leptopoda*, *E. loxophleba* subsp. *lissophloia*, *E. petraea*, *E. salmonophloia*, *E. subangusta* subsp. *cerina* and *E. virella*.

Conservation status. Not yet assessed under the IUCN Red List of Threatened Species (IUCN 2020). Considering its known distribution, life cycle, and threats, we believe that an IUCN Red List category of 'Endangered' is appropriate for the species.

Currently listed as Priority 1 under Conservation Codes for Western Australian Flora (Smith & Jones 2018), as *E. leptophylla* var. *floribunda*. The species has not been recorded in any conserved areas.

Etymology. From the Latin *efflorescens* (to burst into flower). The name was coined by L.A.S. Johnson and K.D. Hill, and may have been chosen as an allusion to

the varietal name of *E. leptophylla* var. *floribunda* (to flower abundantly) and the common name 'Flowery Mallee' used by Blakely (1936). The epithet 'floribunda' could not be used for this taxon at specific rank due to the description of *Eucalyptus floribunda* Hügel ex Endl. in 1837, which is now regarded as a synonym of the distantly related *E. marginata* Donn ex Sm. (Australian Plant Census 2020).

Common names. Flowery Mallee (Blakely 1936), Elachbutting Mallee (French 2012).

Notes. A distinctive species within the series due to its dullish adult leaves and its variably pruinose adult branchlets. It is most closely related to *E. horistes*, from which it differs in its mature canopy often composed of some juvenile leaves, its shorter, broader, dull to slightly glossy adult leaves, and its variably pruinose branchlets. The two species are allopatric, with the distribution of the more widespread *E. horistes* being to the west, north and east of the more restricted distribution of *E. efflorescens*. Intergrades between the two species occur at the western fringe of the distribution of *E. efflorescens*, from north-west of Trayning to east of Bonnie Rock.

Selected specimens

WESTERN AUSTRALIA (west to east). c. 7 miles (11 km) W of Kununoppin, Apr. 1969, *B. Rockel 104* (PERTH); c. 29 km N of Baandee, corner of Ryans Rd, 15 Sep. 1982, *M.I.H. Brooker 7627* (CANB, PERTH); corner of Ryans Rd and Baandee North Rd, 6 Jan. 2007, *D. Nicolle 5033 & M.E. French* (AD, CANB, NSW, PERTH); Nukarin West Rd, NW of Merredin, 13 Nov. 2005, *M.E. French 1723* (PERTH); Elachbutting Rd on N side of Yanneymooning Hill, NE of Mukinbudin, 16 Apr. 2001, *M.E. French 1321* (AD, PERTH).

16. *Eucalyptus fruticosa* Brooker

Brunonia 2(1): 129 (1979). — **Holotype:** 103 miles south of Exmouth, Western Australia, 25 Apr. 1974, *M.I.H. Brooker 4578a* (CANB). **Isotypes:** AD; NSW; PERTH.

Mallee 0.2–6 m tall, often sprawling; lignotuber present, lignotuber resprouter (Nicolle 2006). *Bark* rough on lower stems or up to small branches, ribbony-fibrous, grey, then smooth above, coppery-tan to grey over cream, decorticating annually in strips. *Branchlets* non-pruinose. *Seedling leaves* opposite for many pairs, nodes 10–25 mm apart, sessile, orbicular to ovate, 15–40 mm long × 14–30 mm wide, length:width ratio typically 1–1.4:1, slightly discolorous, dull, grey-green to grey, pruinose. *Coppice leaves* similar but typically larger and more spaced. *Mature crown* usually composed of a mixture of juvenile, intermediate and adult leaves, sometimes fully adult leaves. *Adult leaves* with petioles 5–15 mm long, lamina lanceolate to broad-lanceolate, 40–85 mm long × 6–16 mm wide, length:width ratio typically 4–8:1, glossy, green, non-pruinose; tertiary venation very dense; oil glands numerous, connected to vein network (intersectional oil glands). *Inflorescences* 7–11-flowered; peduncles terete to angular, 3–8 mm long; pedicels 1–3 mm long. *Flower buds* fusiform to diamond-shaped, 7–13 mm long × 3.5–5 mm diam.; opercula conical to beaked, 4–7 mm long, length:width ratio typically 1–1.8:1. *Fruits* cupular to truncate-globose, 5–7 mm long × 5–7 mm diam.; disc near level to steeply descending; valves 3, rim level or below. **Fig. 33.**

Diagnostic characters. Distinguished within *E.* ser. *Porantherae* by the following combination of characters: Lignotuberous mallee. Bark persistent (non-shedding) on lower trunks. Branchlets non-pruinose. Seedling leaves opposite, moderately-spaced, orbicular to ovate (length:width ratio 1–1.4:1), greyish, pruinose (Fig. 34). Mature canopy often composed of a mixture of juvenile, intermediate and adult leaves. Adult leaves lanceolate to broad-lanceolate (length:width ratio 4–8:1), glossy, green. Pedicels short. Opercula conical to beaked. Fruits cupular to truncate-globose.

Illustrations. M.I.H. Brooker & D.A. Kleinig, *Field Guide Eucalypts* 2: 305 (1990); 2nd edn, 2: 305 (2001); 3rd edn, 2: 278 (2016); M.I.H. Brooker & D.A. Kleinig, *Field Guide Eucalypts* 3: 222 (1994); 2nd edn, 3: 222 (2004); A.V. Slee *et al.*, *EUCLID Eucalypts of Australia* CD ROM, *Eucalyptus fruticosa* (2006).

Distribution and habitat. Endemic to W.A., where it is restricted to coastal and near-coastal sites on the far west coast, occurring as scattered populations from the Coral Bay area southwards to Horrocks, including Bernier Island (Fig. 35). It grows on exposed sites, in deep red sand on dunes or rises, always overlying limestone, or on almost pure limestone. Vegetation consists of low *Acacia* or mallee shrubland. Associated eucalypts include *Eucalyptus dolichocera*, *E. erythrocorys*, *E. obtusiflora* subsp. *obtusiflora* and *E. oraria*.

Conservation status. Globally listed as 'Least Concern' on the IUCN Red List of Threatened Species (IUCN 2020). However, considering its known distribution, life cycle, and threats, we believe that an IUCN Red List category of 'Near Threatened' is more appropriate for the species.

Not a listed taxon under Conservation Codes for Western Australian Flora (Smith & Jones 2018). Recorded from Francois Peron and Kalbarri national parks and from Bernier And Dorre Islands and Zuytdorp nature reserves.

Common names. Kalbarri Mallee (Brooker & Kleinig 2016).

Notes. *Eucalyptus fruticosa* is the most northerly and westerly occurring species in *E.* ser. *Porantherae*. For the most part, its distribution does not overlap with any other species in the series, although *E. rigidula* and *E. horistes* can occur nearby in the Kalbarri area. The species can be distinctive in the field due to its low, sprawling habit, its canopy often being a mixture of

Fig. 33. *Eucalyptus fruticosa* habit and habitat. **A** Horrocks, SW of Northampton, W.A.; **B** *D. Nicolle 5569 & M.E. French*, Murchison House Station, W.A.; **C** Gnaraloo Rd, NW of Carnarvon, W.A.; **D** Coburn Station, W.A.; **E** mature plant with juvenile foliage only, S boundary of Hamelin Station, W.A.

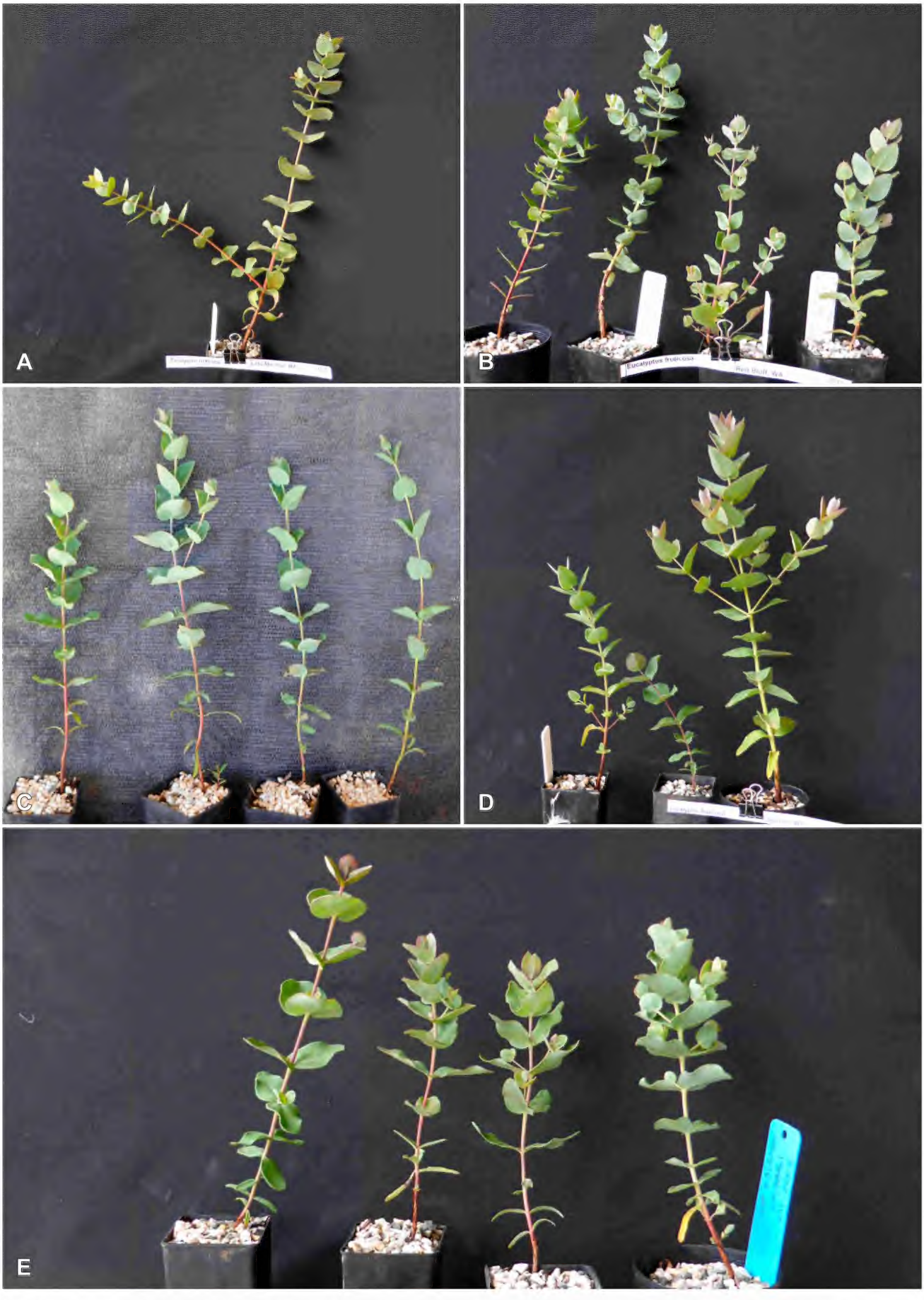

Fig. 34. *Eucalyptus fruticosa* seedlings. **A** F1 of *D. Nicolle 1177*, Quobba Station, W.A.; **B** F1 of *D. Nicolle 3531 & M.E. French*, Red Bluff to Kalbarri township, W.A.; **C** F1 of *D. Nicolle 5567 & M.E. French*, Port Gregory Rd, E of Port Gregory, W.A.; **D** F1 of *M.E. French 2678*, just N of Horrocks, W.A.; **E** F1 of *M.E. French 2836* (PERTH 09190147), SW boundary of Kalbarri N.P., W.A.

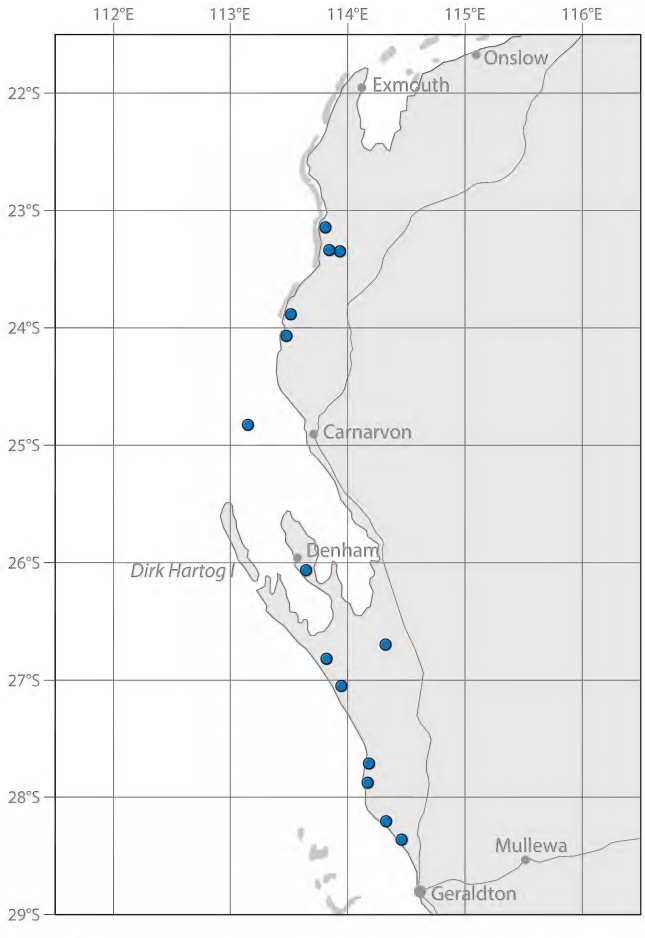

Fig. 35. Distribution of *Eucalyptus fruticosa* in Western Australia.

glossy green adult leaves and dull, greyish juvenile and intermediate leaves.

Eucalyptus fruticosa is most closely related to *E. horistes*, which differs in its canopy, which is consistently composed of adult leaves only, and its smaller, more delicate buds and fruits.

Selected specimens

WESTERN AUSTRALIA (north to south). c. 20 km N of Waroora t/o on Coral Bay rd, 15 Apr. 1977, *M.I.H. Brooker 5698* (AD, CANB, MEL, NSW, PERTH); Waroora Station, c. 5 km ex Exmouth Rd, 6 July 1997, *M.E. French 198* (AD, PERTH); Quobba Station, 28 Nov. 1994, *D. Nicolle 1177* (AD); Hospital Valley, Bernier Island, Shark Bay, 23 July 1959, *R.D. Royce 6017* (PERTH); Denham-Hamlin Rd, S of Denham, 20 Jan. 2007, *D. Nicolle 5082* (CANB, PERTH); c. 18 km towards Coburn Homestead from North West Coastal Hwy, 12 May 1999, *M.I.H. Brooker 12991* (CANB, PERTH); Zuytdorp coastal area, N of Kalbarri N.P., 3 Apr. 1999, *M.E. French 799* (PERTH); c. 1 km from Red Bluff towards Kalbarri township, 29 Oct. 2000, *D. Nicolle 3531 & M.E. French* (CANB, PERTH); SW boundary of Kalbarri N.P., 20 Mar. 2017, *M.E. French 2836* (PERTH); Port Gregory Rd, E of Port Gregory, 28 Mar. 2010, *D. Nicolle 5567 & M.E. French* (CANB, PERTH); Horrocks, N of Township, SW of Northampton, 29 Apr. 2014, *M.E. French 2678* (PERTH).

17. *Eucalyptus rigidula* Maiden

Crit. Rev. Eucalyptus 7(9): 403 (1928). — *Eucalyptus angusta* Maiden, *Crit. Rev. Eucalyptus* 6(6): 265–266, pl. 229 (1922), *nom. illeg.*, *non* Velen. (1885; fossil taxon). — **Type citation:** "Comet Vale, 63 miles north of Kalgoorlie. J.H. Maiden (buds and fruits), September 1909, is the type". **Lectotype:** Comet Vale, Sep. 1909, *J.H. Maiden s.n.* (NSW53339), *fide* Chippend., *Fl. Australia* 19: 281 (1988), as "holo". **Isolectotypes:** CANB422179; K000347524; US00118335.

Mallee to 5 m tall; lignotuber present, lignotuber resprouter (Nicolle 2006). *Bark* loose and ribbony-rough for up to 1 m, otherwise smooth throughout, decorticating annually in strips and ribbons, pale grey and pinkish grey over cream to powdery white. *Branchlets* non-pruinose. *Seedling leaves* opposite for 7–15+ pairs then becoming disjunct, nodes (5–) 10–35 (–58) mm apart, sessile or on petioles to 7 mm long, linear to ovate, 20–95 mm long × 3–28 mm wide, length:width ratio typically 1.5–16:1, slightly discolorous, dull, green to grey-green, non-pruinose. *Coppice leaves* similar but typically larger, more spaced, disjunct and petiolate. *Mature crown* composed entirely of adult leaves. *Adult leaves* with petioles 4–20 mm long, lamina linear to broad-lanceolate, 45–105 mm long × 3–16 (–20) mm wide, length:width ratio typically 5–16:1, glossy, green, non-pruinose; tertiary venation dense; oil glands very scattered or apparently absent, connected to vein network (intersectional oil glands). *Inflorescences* 7–13-flowered; peduncles angular to slightly flattened, 2–15 mm long; pedicels 1–5 mm long. *Flower buds* ovoid to fusiform, 6–11.5 mm long × 2–5 mm diam.; opercula broadly conical to slightly beaked, 2.5–6 mm long, length:width ratio typically 1–1.3:1. *Fruits* truncate-globose to broadly-obconic to cupular to shortly barrel-shaped, 4–9.5 mm long × 3–7 mm diam.; disc level to descending; valves 3 (4), at or below rim level. **Fig. 36.**

Diagnostic characters. Distinguished within *E.* ser. *Porantherae* by the following combination of characters: Lignotuberous mallee. Bark mostly shedding, but ribbony and often accumulated on lower trunks. Branchlets non-pruinose. Seedling leaves opposite initially but soon becoming disjunct, moderately to well-spaced, linear to ovate, green to grey-green, non-pruinose (Fig. 37). Adult leaves linear to broad-lanceolate, glossy and green at all ages. Pedicels usually distinct. Opercula broadly conical to slightly beaked. Fruits truncate-globose to broadly obconic to cupular to shortly barrel-shaped.

Distribution and habitat. Endemic to W.A., occurring over a large area from near the west coast north of Geraldton inland into the Great Victoria Desert north-east of Laverton, including much of the central and northern wheatbelt regions and most of the goldfields region (Fig. 38). It grows in a variety of habitats including deep sandplains and broad rises in a variety

Fig. 36. *Eucalyptus rigidula*. **A** subsp. *rigidula* (*D. Nicolle 5578 & M.E. French*, near Warran Jababba Spring, Eurady Station, W.A.); **B** subsp. *interior* (*D. Nicolle 6955 & M.E. French*, Cable Haul Rd, S of PNC Baseline Rd, W.A.); **C** subsp. *clancularia* (*D. Nicolle 7987 & M.E. French*, N of Mt Andrew, W.A.).

of well-drained substrates, including commonly on sandplain or on broad gravelly hills.

Conservation status. Globally listed as 'Least Concern' on the IUCN Red List of Threatened Species (IUCN 2020). We concur with this assessment.

Not a listed species under Conservation Codes for Western Australian Flora (Smith & Jones 2018).

We below suggest conservation codes for the three subspecies of *E. rigidula* using IUCN and Conservation Codes for Western Australian Flora assessment methodology.

Common names. Stiff-leaved Mallee (Chippendale 1988; French 2012; Brooker & Kleinig 2016), Thick-rimmed Mallee (French 2012).

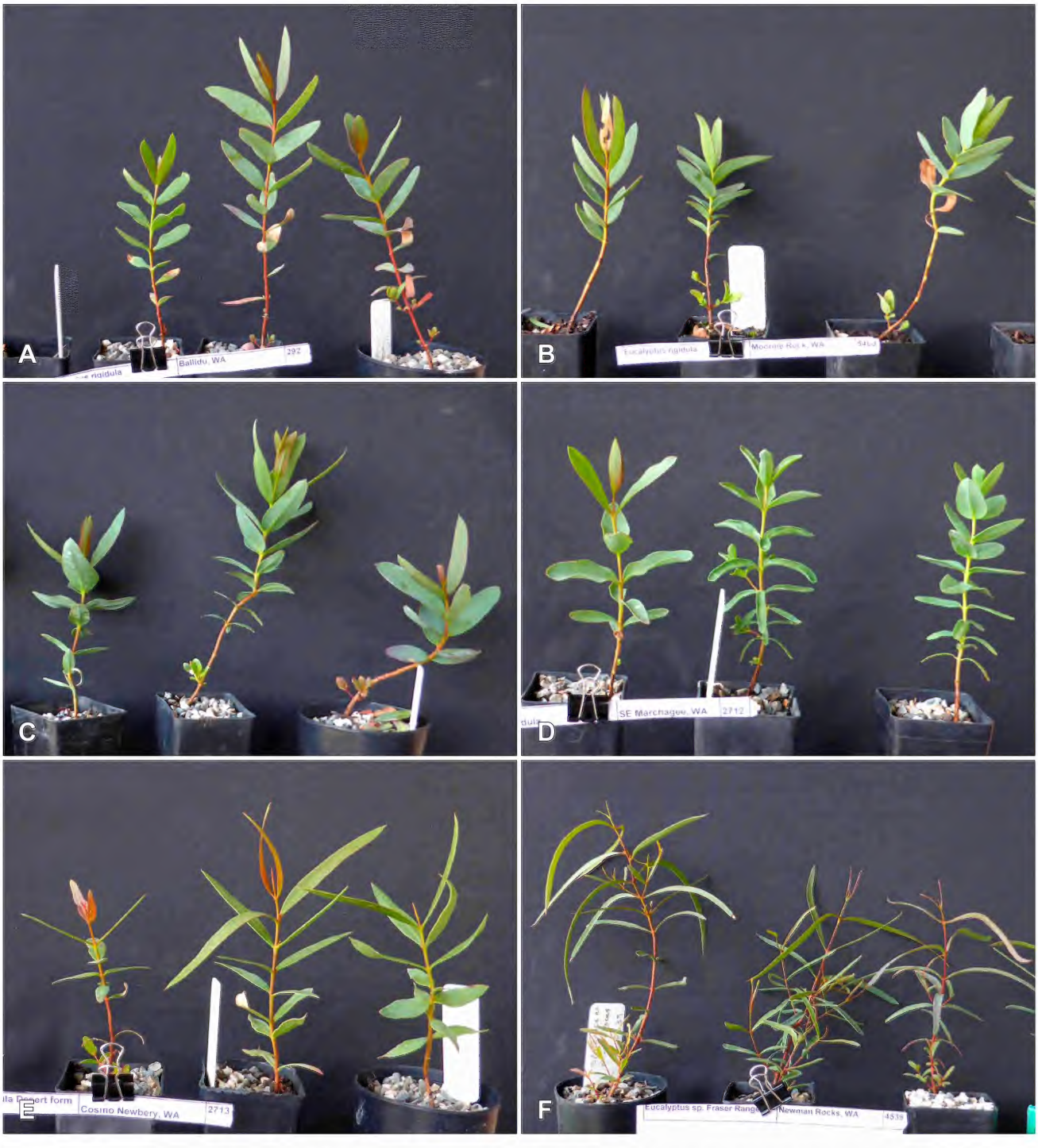

Fig. 37. *Eucalyptus rigidula* seedlings. **A** subsp. *rigidula* (F1 of *D. Nicolle 292*, between Ballidu and Wongan Hills, W.A.); **B** subsp. *rigidula* (F1 of *D. Nicolle 5460 & M.E. French*, Gobetti Rd, SE of Moorine Rock, W.A.); **C** subsp. *rigidula* (F1 of *D. Nicolle 5554 & M.E. French*, Thomas Rd, W of Wubin, W.A.); **D** subsp. *rigidula* (F1 of *M.E. French 2712*, Thomas Rd, E of Marchagee, W.A.); **E** subsp. *interior* (F1 of *D. Nicolle 2713 & J. Connors*, Great Central Rd, Great Victoria Desert, W.A.); **F** subsp. *clancularia* (F1 of *D. Nicolle 4539 & M.E. French*, Newman Rock picnic area, NW of Balladonia, W.A.).

Notes. *Eucalyptus rigidula* is a well-defined species. It is most likely to be confused with the superficially similar *E. dissimulata*, which can be distinguished most reliably in its adult leaves, which have numerous visible oil glands (Fig. 39). *Eucalyptus dissimulata* also differs from *E. rigidula* in its lesser accumulation of ribbony bark, its consistently non-powdery bark, its narrowly elliptic to almost orbicular and consistently dull seedling leaves, and its typically more cupular fruits.

Eucalyptus rigidula can be associated with a number of other *E.* ser. *Porantherae* taxa, including *E. horistes*, *E. olivina*, and *E. plumula*. Hybrids between *E. rigidula* and these other *E.* ser. *Porantherae* taxa are not known.

Three geographic subspecies are recognised in *E. rigidula*, differing in the colour, shape and development of their seedling leaves, the shape of their adult leaves, the

length of their peduncles and pedicels, and the size of their buds and fruits.

17a. *Eucalyptus rigidula* Maiden subsp. *rigidula*

Eucalyptus uncinata var. *major* Benth., *Fl. Austral.* 3: 216 (1867). — **Type citation:** "Murchison river, *Oldfield*". **Lectotype (here designated):** Murchison, W.A., 1866, *A. Oldfield s.n.* (NSW350252).

Eucalyptus sp. Kalbarri (*M.I.H. Brooker 7937*): D.Nicolle *et al.*, *Nuytsia* 22(3): 103 (2012).

Eucalyptus sp. Kalbarri (*M.I.H. Brooker 7937*): Slee *et al.*, *Euclid: Eucalypts Austral. Ed. 4* (2015).

Seedling leaves opposite for 11–15+ pairs then becoming disjunct, ovate or elliptic to broad-lanceolate (becoming lanceolate), length:width ratio typically 1.5–5:1, green to grey-green. *Adult leaves* (narrow-lanceolate to) lanceolate (to broad-lanceolate), 5–16 (–20) mm wide, length:width ratio typically 5–11:1. *Inflorescence* peduncles 5–15 mm long; pedicels 1.5–4 mm long. *Flower buds* 6–11.5 mm long × 3–5 mm diam. *Fruits* 4.5–9.5 mm long × 4.5–7 mm diam.

Diagnostic characters. Distinguished within *E. rigidula* by its seedling leaves, which are ovate or elliptic to broad-lanceolate (length:width ratio 1.5–5:1) and become disjunct relatively late (Fig. 37). It also differs from subsp. *clancularia* D.Nicolle & M.E.French by its typically lanceolate adult leaves and its relatively long peduncles and pedicels. Its buds and fruits are variable in size but are sometimes relatively large.

Illustrations. M.E. French, *Eucalypts W. Austral. Wheatbelt* 255 (2012), habit and bark images.

Distribution and habitat. Endemic to W.A., occurring from Nerren Nerren Station (north-east of Kalbarri) and the west coast at Kalbarri, southwards to near Newdegate in the wheatbelt and eastwards to the Kalgoorlie area in the central goldfields (Fig. 38). It grows in a variety of habitats including deep sandplains, broad rises and hills, in a variety of well-drained substrates including yellow to red sands, lateritic gravel and red to brown loams. Occurs as a component of open mallee or mallee shrubland vegetation. Associated eucalypts include *Eucalyptus burracoppinensis*, *E. comitae-vallis*, *E. dolichocera*, *E. eudesmioides*, *E. gittinsii* subspp. *gittinsii* and *illucida*, *E. leptopoda* subspp. *arctata*, *leptopoda* and *subluta*, *E. obtusiflora*, *E. olivina*, *E. pileata*, *E. platycorys* and *E. sporadica*.

Conservation status. The subspecies is not yet assessed under the IUCN Red List of Threatened Species (IUCN 2020). Considering its known distribution, life cycle, and threats, we believe that an IUCN Red List category of 'Least Concern' is appropriate for the subspecies.

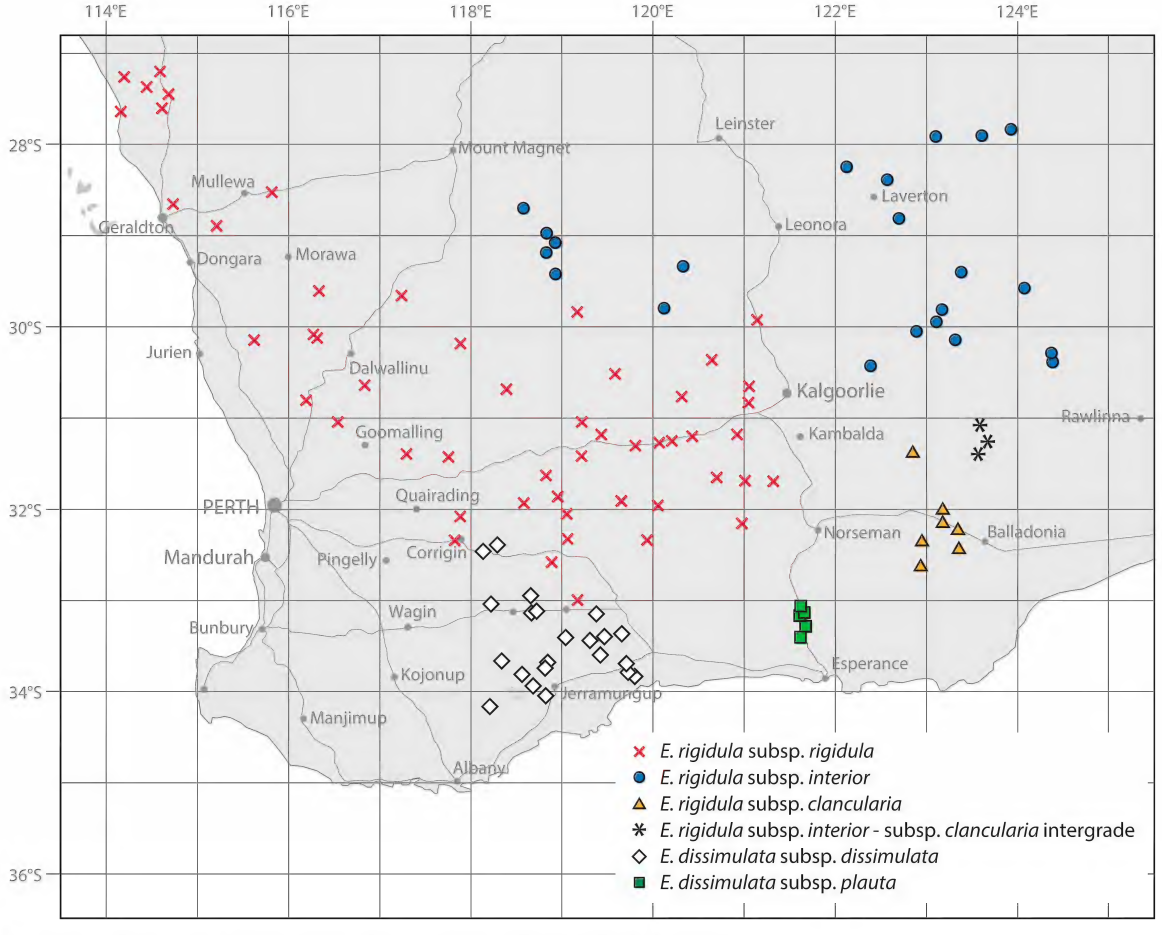

Fig. 38. Distribution of *Eucalyptus rigidula* and *E. dissimulata* in Western Australia.

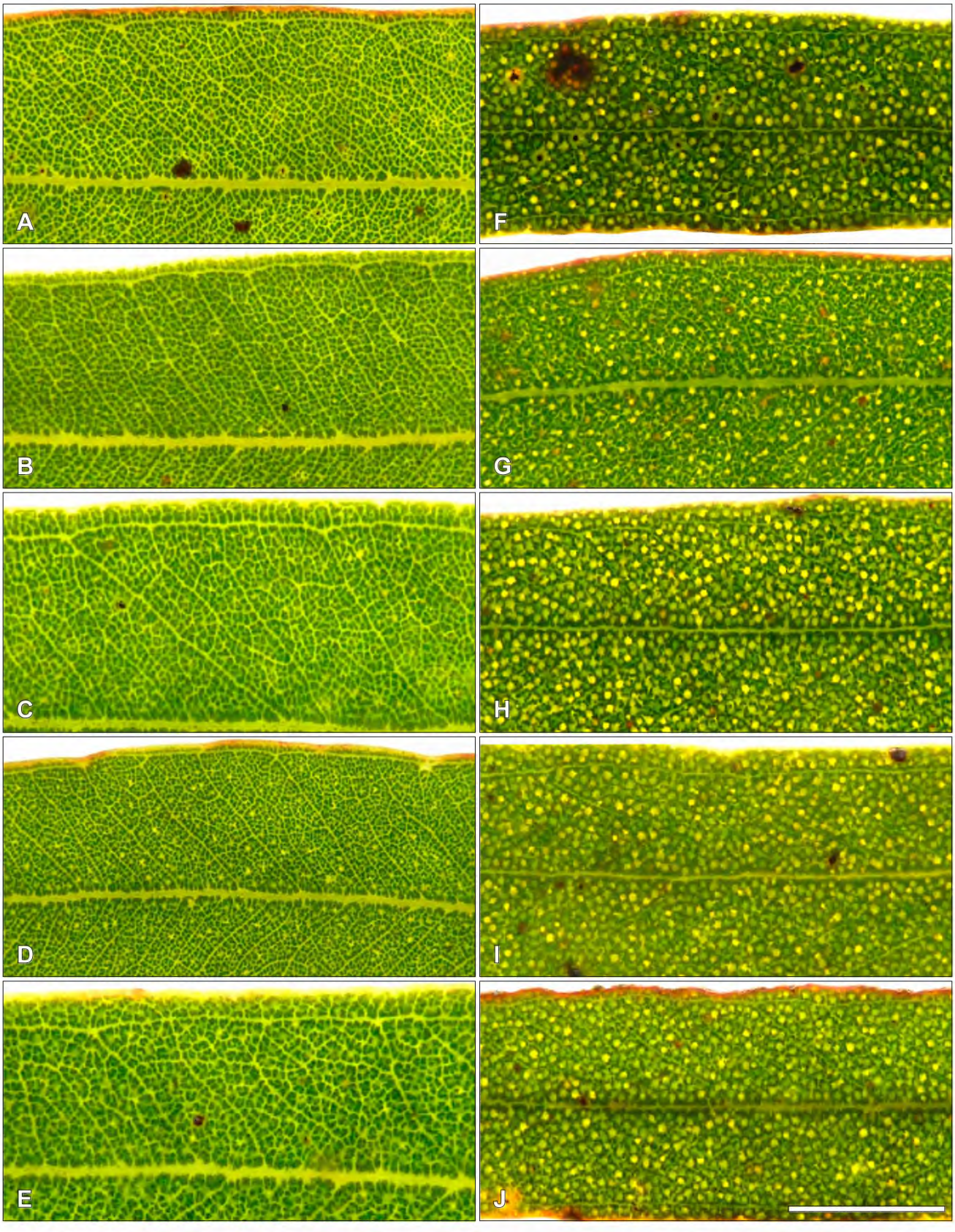

Fig. 39. Fresh adult leaves of *Eucalyptus rigidula* and *E. dissimulata* with transmitted light. **A–E** *E. rigidula*: **A** subsp. *rigidula* (F1 of *D. Nicolle 292*, between Ballidu and Wongan Hills, W.A.); **B** subsp. *rigidula* (F1 of *D. Nicolle 3530 & M.E. French*, S of Kalbarri township, W.A.); **C** subsp. *rigidula* (F1 of *D. Nicolle 5460 & M.E. French*, Gobetti Rd, SE of Moorine Rock, W.A.); **D** subsp. *rigidula* (F1 of *D. Nicolle 5554 & M.E. French*, Thomas Rd, W of Wubin, W.A.); **E** subsp. *rigidula* (F1 of *D. Nicolle 6697 & M.E. French*, Waterbidden Rd, SW of Holleton, W.A.). **F–J** *E. dissimulata*: **F** subsp. *dissimulata* (F1 of *D. Nicolle 205*, W of Jerramungup towards Ongerup, W.A.); **G** subsp. *dissimulata* (F1 of *D. Nicolle 1629*, N of Needilup, W.A.); **H** subsp. *dissimulata* (F1 of *D. Nicolle 3567 & M.E. French*, Hamersley Drive, Fitzgerald River N.P., W.A.); **I** subsp. *dissimulata* (F1 of *D. Nicolle 3744 & M.E. French*, Rabbit Proof Fence Rd, W.A.); **J** subsp. *plauta* (F1 of *D. Nicolle 3897 & M.E. French*, Guests Rd, W.A). Scale = 5 mm.

Not a listed taxon under Conservation Codes for Western Australian Flora (Smith & Jones 2018). Recorded from a number of reserves throughout its distribution, including Boorabbin and Kalbarri national parks and Namelcatchem and East Yuna nature reserves.

Notes. *Eucalyptus rigidula* subsp. *rigidula* occurs in the north-western part of the distribution of the species, and differs from the other two subspecies in its dull, ovate or elliptic to broad-lanceolate seedling leaves that become disjunct relatively late.

The buds and fruits of subsp. *rigidula* are largest in the north-western part of its range, in the Kalbarri area, and gradually become smaller to the south-east. On the basis of their dull, broad seedling leaves and large buds and fruits, the Kalbarri populations were referred to as *E.* sp. Kalbarri by Nicolle *et al.* (2012) and Slee *et al.* (2015), partly on the erroneous presumption that 'typical' *E. rigidula* was the 'desert variant' (the type of *E. rigidula* being from Comet Vale, north of Kalgoorlie). Seedlings subsequently grown by us from Comet Vale have broad seedling leaves that become disjunct late, matching other populations from the west coast and wheatbelt regions. We therefore now include the Kalbarri populations in the type variant of *E. rigidula* (i.e. subsp. *rigidula*), with the Comet Vale population being the most eastern occurrence of subsp. *rigidula* of which we are aware.

We cannot distinguish *Eucalyptus rigidula* subsp. *rigidula* from subsp. *interior* D.Nicolle & M.E.French using adult morphology alone. Intergrades between these subspecies are difficult to detect in the field, as they can only be identified using seedling morphology (or presumably genetically). Seedling trials have detected intergrades in the Lake Barlee area, and they are likely to occur more commonly where the distributions of the two subspecies adjoin, in a line from Paynes Find to north-east of Kalgoorlie.

Eucalyptus rigidula subsp. *rigidula* differs from subsp. *clancularia* in its duller, ovate or elliptic to broad-lanceolate seedling leaves that become disjunct relatively late, but also in its generally broader adult leaves, its relatively longer peduncles and pedicels, and its relatively larger buds and fruits. These two subspecies are not in geographic contact, being separated by the distribution of subsp. *interior*. Some populations of *E. rigidula* subsp. *rigidula* from the Marvel Loch to South Ironcap area tend towards subsp. *clancularia* in their relatively narrow adult leaves, but do not have the short peduncles and pedicels that are characteristic of subsp. *clancularia*.

Selected specimens

WESTERN AUSTRALIA (west to east). S of Kalbarri township, 29 Oct. 2000, *D. Nicolle 3530 & M.E. French* (CANB, PERTH); 21.5 km W along cut line, N of Kalbarri N.P., 22 Nov. 1986, *M.I.H. Brooker 9564* (PERTH); Nerren Nerren Station, NE of Kalbarri, 29 Apr. 2014, *M.E. French 2682* (PERTH); near Warran Jababba Spring, Eurady Station, 29 Mar. 2010, *D. Nicolle 5578 & M.E. French* (AD, CANB, PERTH); just S of Mt Lamb, McGillivray property, SE of Moora, 12 Jan. 2007, *D. Nicolle 5071 & M.E. French* (AD, CANB, PERTH); Thomas Rd, E of Marchagee, 5 Sep. 2014, *M.E. French 2712* (PERTH); Thomas Rd, W of Wubin, 27 Mar. 2010, *D. Nicolle 5554 & M.E. French* (CANB, PERTH); 13.2 km NE of Calingiri on Wongan Hills rd, 28 Aug. 1983, *M.I.H. Brooker 8287* (CANB, PERTH); between Ballidu and Wongan Hills, 13 Dec. 1992, *D. Nicolle 292* (AD); Bencubbin-Kellerberrin Rd, S of Trayning, 22 Aug. 2014, *M.E. French 2706* (PERTH); Trehernes Rd, SW of Bruce Rock, SE of Shackleton, 15 July 2014, *M.E. French 2689* (PERTH); Wadderin-Graball Rd, NE of Narembeen, 1 Sep. 2014, *M.E. French 2711* (PERTH); Aylmore Rd, S of Hyden, 30 July 2014, *M.E. French 2703* (PERTH); Waterbidden Rd, SW of Holleton, 24 Nov. 2013, *D. Nicolle 6697 & M.E. French* (PERTH); Perilya Rd, SE Bullfinch, 11 Aug. 2019, *M.E. French 3201* (PERTH); Gobetti Rd, SE of Moorine Rock, 20 Mar. 2010, *D. Nicolle 5460 & M.E. French* (CANB, PERTH); Ghooli-Koolyanobbing Rd, NE of Southern Cross, 2 Dec. 2016, *M.E. French 2906* (PERTH); between Koolyanobbing and the Helena and Aurora Ra., 20 July 2010, *D. Nicolle 5671 & M.E. French* (AD); E of cross rds on Hyden-Norseman Rd, E of Hyden, 23 Nov. 2019, *M.E. French 3232* (PERTH); E of emu fence on Great Eastern Hwy, E of Yellowdine, 11 Aug. 2019, *M.E. French 3204* (PERTH); NW of Coolgardie on Jaurdi Hills Rd, 8 Oct. 2010, *M.E. French 3441* (PERTH); E of Victoria Rock Rd, on track to Cave Hill, W of Widgiemooltha, 26 Sep. 2014, *M.E. French 2731* (PERTH); N of Comet Vale towards Menzies, 31 Oct. 2015, *M.E. French 2825* (PERTH).

17b. *Eucalyptus rigidula* subsp. *interior* D.Nicolle & M.E.French, *subsp. nov.*

Holotypus: Western Australia, c. 40.7 km SE of Laverton on the Jasper Hill road, 17 July 1999, *J.R. Connors 1003 & D. Nicolle* (PERTH06127452). **Isotypi:** CANB512703; NSW500705.

Seedling leaves opposite for 8–12 pairs then becoming disjunct, linear to narrow-lanceolate (becoming lanceolate), length:width ratio typically 6–14:1, green. *Adult leaves* (narrow-lanceolate to) lanceolate (to broad-lanceolate), 6–18 mm wide, length:width ratio typically 5–10:1. *Inflorescence* peduncles 6–15 mm long; pedicels 2–5 mm long. *Flower buds* 7–10 mm long × 3–5 mm diam. *Fruits* 4–6 mm long × 4–5 mm diam.

Diagnostic characters. Distinguished within *E. rigidula* by its seedling leaves, which are linear to narrow-lanceolate (length:width ratio 6–14:1) and become disjunct relatively early (Fig. 37). It also differs from subsp. *clancularia* by its typically lanceolate adult leaves and its relatively long peduncles and pedicels. Its buds and fruits are variable in size but not as large as sometimes seen in subsp. *rigidula* nor as small as often seen in subsp. *clancularia*.

Distribution and habitat. Endemic to W.A., occurring from south-east of Mount Magnet eastwards to north-east of Laverton, extending southwards to Diemals

and the Zanthus area (Fig. 38). It typically grows on sandplains or low rises of red to yellow sand to sandy-loam, usually overlying limestone. It grows as a component of open mallee or *Acacia* shrubland, usually with a *Triodia* groundstorey. Associated eucalypts include *Eucalyptus concinna*, *E. gongylocarpa*, *E. hypolaena*, *E. kochii* subsp. *amaryssia*, *E. leptopoda* subspp. *elevata*, 'Glaucous' and *subluta*, *E. longissima*, *E. lucasii*, *E. mannensis* subsp. *mannensis*, *E. oldfieldii*, *E. pimpiniana*, *E. platycorys*, *E. plumula*, *E. rosacea* and *E. youngiana*.

Conservation status. The subspecies is not yet assessed under the IUCN Red List of Threatened Species (IUCN 2020). Considering its s known distribution, life cycle, and threats, we believe that an IUCN Red List category of 'Least Concern' is appropriate for the subspecies.

Not a listed taxon under Conservation Codes for Western Australian Flora (Smith & Jones 2018). Recorded from Queen Victoria Spring Nature Reserve.

Etymology. From the Latin *interior* (inner), referring to its inland distribution compared to subspp. *rigidula* and *clancularia*.

Notes. *Eucalyptus rigidula* subsp. *interior* is the 'desert' variant of the species, occurring north-east of the distribution of subsp. *rigidula* and north of the distribution of subsp. *clancularia*.

Eucalyptus rigidula subsp. *interior* differs from subsp. *rigidula* in its greener, linear to narrow-lanceolate seedling leaves that become disjunct relatively early. We cannot distinguish the two subspecies based on adult material alone, and therefore intergrades between these subspecies are difficult to detect in the field without seedlings.

Eucalyptus rigidula subsp. *interior* differs from subsp. *clancularia* in its generally broader adult leaves, its relatively longer peduncles and pedicels, and its relatively larger buds and fruits. Intergrades between *E. rigidula* subspp. *interior* and *clancularia* occur in the area where their respective distributions adjoin (to the south-east of the distribution of subsp. *interior*), in the area from Karonie to the northern part of the Fraser Range south of Zanthus.

Selected specimens

WESTERN AUSTRALIA (west to east). Paynes Find-Sandstone Rd, Youanmi Downs Station, 29 Oct. 2015, *M.E. French 2811* (PERTH); tk to Browns Soak, S of Youanmi, 14 May 2017, *D. Nicolle 7310 & M.E. French* (PERTH); SW of Lake Barlee Station homestead, 28 Aug. 2020, *M.E. French 3384* (PERTH); sandalwood tk, NW of Diemals homestead, 22 Oct. 2016, *M.E. French 2896* (PERTH); 19 km S of Number 5 Well, SE of Sandstone to Menzies, 28 May 2000, *M.I.H. Brooker 9658* (CANB); on tk 5.7 km N of Hospital Rocks off Evanston Menzies Rd, 8 Oct. 2010, *M.E. French 3427* (PERTH); 56.8 km S of Kookynie turnoff, 4 Nov. 1983, *M.I.H. Brooker 8339* (PERTH); 0.4 km E of gate, Goongarrie Nature Reserve, 6 May 1987, *M.I.H. Brooker 9610* (PERTH); Erlistoun Station, NE of homestead, NW of Laverton, 30 Oct. 2015, *M.E. French 2820* (PERTH); E of Yowie Hill, on Kurnalpi-Pinjin Rd, NE of Kalgoorlie, 28 Dec. 2018, *M.E. French 3089* (PERTH); 55 km E of Karonie, 7 May 1987, *M.I.H. Brooker 9621* (PERTH); 154.7 km N of Laverton turnoff on rd to Warburton, 13 June 2002, *A.V. Slee 4489* (CANB); c. 226 km by rd SW of Alexander Springs turnoff towards Cosmo Newberry on the Warburton to Cosmo Newberry rd, Great Victoria Desert, 16 July 1999, *D. Nicolle 2713 & J. Connors* (AD); Cable Haul Rd, S of PNC Baseline Rd, 29 Apr. 2015, *D. Nicolle 6955 & M.E. French* (PERTH).

17c. *Eucalyptus rigidula* subsp. *clancularia* D.Nicolle & M.E.French, *subsp. nov.*

Holotypus: Western Australia, 33.8 km NW of Balladonia towards Norseman, 10 Feb. 1985, *M.I.H. Brooker 8836* (PERTH01378961). **Isotypus:** CANB430650; MEL1611611; NSW350428.

Eucalyptus sp. Fraser Range (*D. Nicolle 2157*): D.Nicolle *et al.*, *Nuytsia* 22(3): 103 (2012).

This subspecies had previously been recognised under the designation *Eucalyptus* 'clancularia' (Hill ms; Slee *et al.* 2006), but a name was never formally published.

Seedling leaves opposite for 7–11 pairs then becoming disjunct, linear to narrow-lanceolate, length:width ratio typically 7–16:1, green (Fig. 37). *Adult leaves* linear to narrow-lanceolate (to lanceolate), 3–10 mm wide, length:width ratio typically 8–16:1. *Inflorescence* peduncles 2–5 (–8) mm long; pedicels 1–2.5 mm long. *Flower buds* 6–8.5 mm long × 2–4 mm diam. *Fruits* 4–5.5 mm long × 3–5.5 mm diam.

Diagnostic characters. Distinguished within *E. rigidula* by its seedling leaves, which are linear to narrow-lanceolate (length:width ratio 7–16:1) and become disjunct relatively early, its relatively narrow, linear to narrow-lanceolate adult leaves (length:width ratio 8–16:1), and its relatively short peduncles and pedicels. Its buds and fruits are variable in size but are usually smaller than in subspp. *rigidula* and *interior*.

Distribution and habitat. Endemic to W.A., occurring from east of Lake Cowan south-east towards Balladonia, and north-east to the Harris Lake area, and centred on the Fraser Range (Fig. 38). It typically grows on sites that are relatively high in the landscape, such as broad rises, in stony, gravelly, sandy or loamy, reddish to brown soil overlying granite or limestone. Outcropping granite is common. It occurs as a component of mallee or *Allocasuarina* shrubland or in open woodland. Associated eucalypts include *Eucalyptus balladoniensis*, *E. gracilis*, *E. grossa*, *E. cylindrocarpa*, *E. delicata*, *E. diptera*, *E. effusa* subsp. *effusa*, *E. histophylla*, *E. horistes*, *E. laevis*, *E. oleosa* subsp. *oleosa*, *E. optima*, *E. planipes*, *E. platycorys*, *E. prolixa*, *E. spreta*, *E. terebra*, *E. urna* and *E. websteriana*.

Conservation status. The subspecies is not yet assessed under the IUCN Red List of Threatened Species (IUCN 2020). Considering its known distribution, life cycle, and threats, we believe that an IUCN Red List category of 'Near Threatened' is appropriate for the subspecies.

Not a listed taxon under Conservation Codes for Western Australian Flora (Smith & Jones 2018). A number of populations occur in Dundas Nature Reserve.

Etymology. From the Latin *clancularia* (anonymous, secret, concealed). It is not clear who originally coined the name, nor their intended meaning of the name. Ironically, the name is apt for that very reason.

Notes. *Eucalyptus rigidula* subsp. *clancularia* occurs at the south-eastern end of the distribution of the species, and differs from the other two subspecies in its narrow, linear to narrow-lanceolate adult leaves and its relatively short peduncles and pedicels. Its buds and fruits are also typically smaller than in the other two subspecies.

Intergrades between *E. rigidula* subspp. *clancularia* and *interior* occur in the area where their respective distributions adjoin (to the north of the distribution of subsp. *clancularia*), in the Karonie area to south of Zanthus.

Eucalyptus rigidula subsp. *clancularia* sometimes co-occurs with another *E.* ser. *Porantherae* taxon, *E. horistes*. While the two taxa can be distinguished by subtle differences in their adult morphology (e.g. the adult leaf length:width ratio is 8–16:1 in *E. rigidula* subsp. *clancularia* and 5–7.5:1 in *E. horistes*), their seedling and coppice growth morphology is very different, with *E. rigidula* subsp. *clancularia* having narrow, green, non-pruinose seedling and coppice leaves that soon become disjunct and petiolate, while *E. horistes* has orbicular to cordate, greyish, pruinose seedling and coppice leaves that remain opposite and sessile for many pairs.

Selected specimens

WESTERN AUSTRALIA (west to east). c. 9 km north of granite outcrops on sandalwood cutter's tk towards Chilfey, 22 May 2017, *D. Nicolle 7337* (PERTH); track to Mt Andrew from Optus telegraph track, 16 Jan. 2021, *D. Nicolle 7987 & M.E. French* (AD, PERTH); c. 30 km SW of Eyre Hwy on Harms Lake tk, 15 Jan. 2021, *D. Nicolle 7982 & M.E. French* (PERTH); new mining access tk in area N of Newman Rock, 30 Apr. 2015, *D. Nicolle 6976 & M.E. French* (PERTH); Newman Rock, N of Eyre Hwy, NW of Balladonia, 1 Mar. 2003, *D. Nicolle 4539* (AD); from Eyre Hwy on Newman Rocks tk, W of Balladonia, 16 Dec. 2000, *M.E. French 1243* (PERTH); N of Hwy on tk to Newmans Rock, c. 49 km W of Balladonia Roadhouse, 10 Oct. 1983, *K. Hill 226 & L. Johnson* (CANB, NSW, PERTH); Newman Rock, between Fraser Ra. and Balladonia, 15 Sep. 1999, *M.I.H. Brooker 13018* (CANB); Newman Rock, between Fraser Ra. and Balladonia, 15 Sep. 1999, *M.I.H. Brooker 13019* (CANB); along tk to Newman Rocks, W of Balladonia on the Eyre Hwy, 29 Oct. 2013, *L.S.J. Sweedman 8675* (PERTH); Optus telegraph tk, SW of Balladonia roadhouse, 16 Jan. 2021, *D. Nicolle 7994 & M.E. French* (PERTH); Eyre Hwy, between Balladonia and Fraser Ra., 30 Apr. 2015, *D. Nicolle 6973 & M.E. French* (PERTH); Eyre Hwy between Balladonia Roadhouse and Fraser Ra., 11 Apr. 1998, *D. Nicolle 2157* (PERTH).

18. *Eucalyptus dissimulata* Brooker

Nuytsia 6(3): 332–333, Figs 1, 2e, 3e (1988). — **Holotype:** 30.3 km N of Needilup just S of Rabbit Proof Fence road, 30 Nov. 1984, *M.I.H. Brooker 8748* (PERTH1380265). **Isotypes:** AD98747024; CANB412295 [ex FRI]; MEL0686105; NSW349722.

Mallee to 6 m tall, rarely to 12 m tall; lignotuber present, lignotuber resprouter (Nicolle 2006). *Bark* rough and fibrous in larger individuals, otherwise smooth throughout, decorticating annually in strips, grey to pale grey. *Branchlets* non-pruinose. *Seedling leaves* opposite for 3–18+ pairs then becoming disjunct, nodes 6–18 mm apart, sessile or on petioles to 1.5 mm long, narrowly elliptic to almost orbicular, 12–32 mm long × 5–16 mm wide, length:width ratio typically 1.5–3.8:1, slightly discolorous, dull, green to grey-green, non-pruinose. *Coppice leaves* similar but typically larger, more spaced, disjunct and becoming petiolate. *Mature crown* composed entirely of adult leaves. *Adult leaves* with petioles 4–15 mm long, lamina narrow (near linear to) lanceolate (to broad-lanceolate), 45–110 mm long × 5–22 mm wide, length:width ratio typically 5–11:1, dull or glossy and blue-green to green initially, maturing glossy and green to dark green, non-pruinose; tertiary venation dense; oil glands numerous, connected to vein network (intersectional oil glands). *Inflorescences* 7–9 (–15)-flowered; peduncles terete to slightly flattened, 4–12 (–20) mm long; pedicels 1–3 mm long. *Flower buds* ovoid to diamond-shaped, 7–12 mm long × 3–6 mm diam.; opercula bluntly to acutely conical, 3–7 mm long, length:width ratio typically 0.9–1.6:1. *Fruits* truncate globose to cupular to shortly barrel-shaped, 4–7 mm long × 4–7 mm diam.; disc level to descending; valves 3 (4), at rim level or below.

Diagnostic characters. Distinguished within *E.* ser. *Porantherae* by the following combination of characters: Lignotuberous mallee. Bark smooth and shedding throughout. Branchlets non-pruinose. Seedling leaves opposite initially then becoming disjunct, moderately-spaced, narrowly elliptic to almost orbicular, green to grey-green, non-pruinose (Fig. 40). Adult leaves typically near linear to broad lanceolate, maturing glossy and green. Pedicels distinct. Opercula bluntly to acutely conical. Fruits truncate-globose to cupular to shortly barrel-shaped.

Distribution and habitat. Endemic to W.A., where it is widely distributed near the south coast from Borden eastwards to the Grasspatch area, and inland to the Kondinin area (Fig. 38). It grows in mallee shrubland or mixed mallee woodland vegetation on mostly level topography in pale-coloured sands and loams overlying clay and/or limestone.

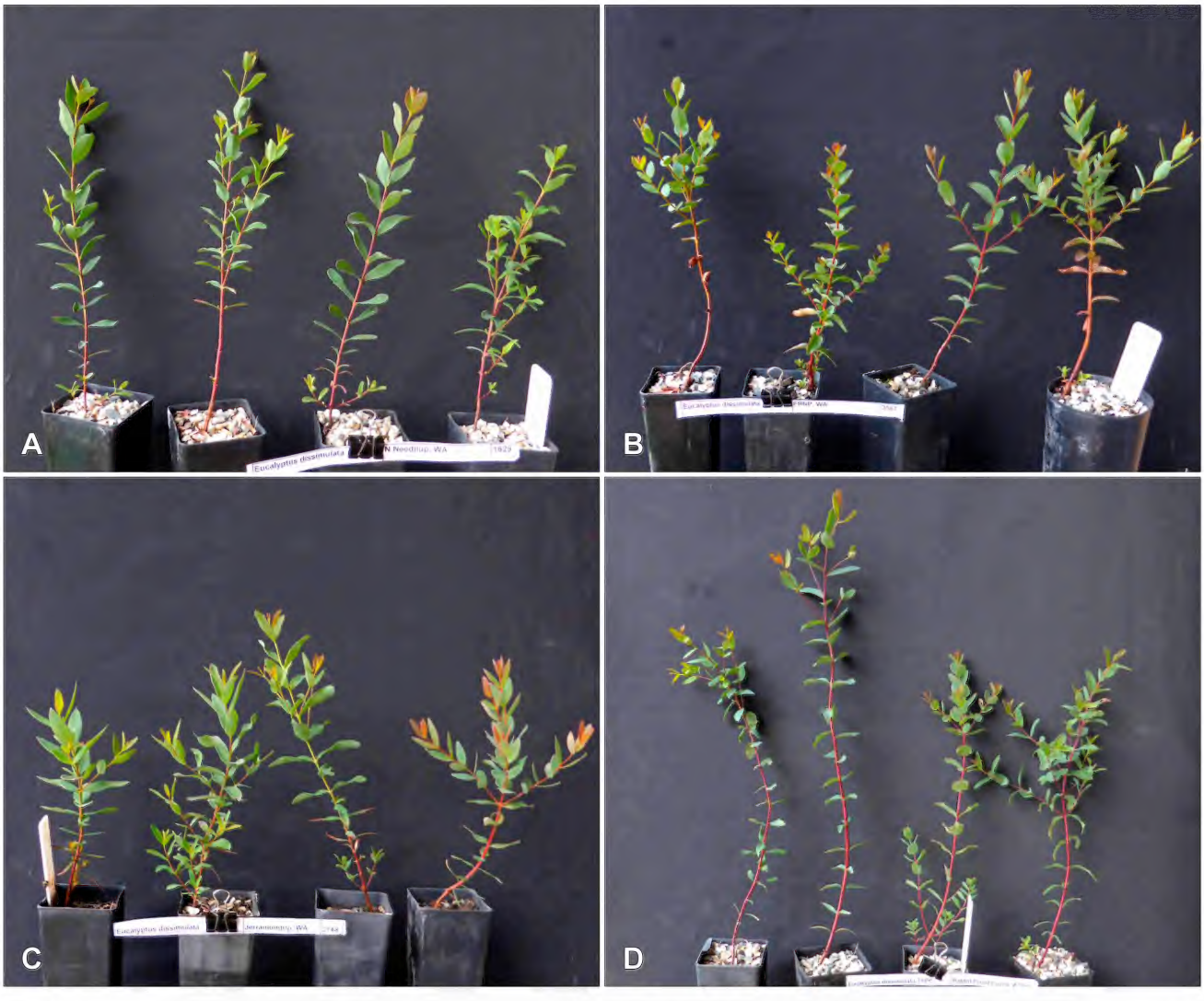

Fig. 40. *Eucalyptus dissimulata* subsp. *dissimulata* seedlings. **A** F1 of *D. Nicolle 1629*, N of Needilup, W.A.; **B** F1 of *D. Nicolle 3567 & M.E. French*, Hamersley Drive, Fitzgerald River N.P., W.A.; **C** F1 of *M.E. French 2748*, Stock Rd, SW of Jerramungup, W.A.; **D** F1 of *M.E. French 2749*, N of Rabbit Proof Fence Rd, NE of Ongerup, W.A.

Conservation status. Globally listed as 'Endangered' on the IUCN Red List of Threatened Species (IUCN 2020). We believe this assessment overstates the level of threat to *E. dissimulata*, as it is well represented in several reserves. Considering its known distribution, life cycle, and threats, we believe that an IUCN Red List category of 'Near Threatened' is more appropriate for the species.

The species is not a listed taxon under Conservation Codes for Western Australian Flora (Smith & Jones 2018).

We below suggest conservation codes for the two subspecies of *E. dissimulata* using IUCN and Conservation Codes for Western Australian Flora assessment methodology.

Common names. Red-capped Mallee (Brooker & Kleinig 1990; French 2012; Brooker & Kleinig 2016; French & Nicolle 2019).

Notes. *Eucalyptus dissimulata* is most likely to be confused with the superficially similar *E. rigidula*, which can be distinguished most reliably in its adult leaves, which have few or no visible oil glands (Fig. 39). *Eucalyptus rigidula* also differs from *E. dissimulata* in its accumulation of ribbony bark on the lower trunks, its variably powdery smooth bark, its linear to ovate seedling leaves which become glossy early, and its typically more truncate-globose fruits.

Eucalyptus dissimulata has historically been confused with *E. albida*, which differs most conspicuously in its strongly pruinose, whitish juvenile (seedling and coppice) foliage, which is sometimes present as coppice growth on the lower trunks. *Eucalyptus albida* also differs from *E. dissimulata* in its seasonally powdery bark, its more patchy or tiered canopy, its more rounded opercula, and its twisted style in the bud. There are many other differences in the bark, adult leaves, buds, and fruits, but these are relatively subtle and require much experience to reliably discriminate the two species.

Eucalyptus rigidula can be associated with a number of other *E.* ser. *Porantherae* taxa, including *E. connexa* D.Nicolle & M.E.French and *E. lunata*. Hybrids between *E. dissimulata* and these other *E.* ser. *Porantherae* taxa have not been recorded.

Two geographic subspecies are recognised in *E. dissimulata*, differing in their adult leaves. The distribution of the more westerly-distributed subsp. *dissimulata* appears to be isolated from that of the more easterly-distributed subsp. *plauta*, as there are no collections of the species in the intervening area from the Ravensthorpe Range to the Lort River, over a range of about 140 km.

18a. *Eucalyptus dissimulata* Brooker subsp. *dissimulata*

Adult leaves (near linear to) narrow lanceolate to lanceolate (length:width ratio 6–11:1), 45–105 mm long × 5–15 mm wide, consistently glossy and green to dark green.

Diagnostic characters. Distinguished from *E. dissimulata* subsp. *plauta* by its typically narrower adult leaves which are glossy and green to dark green at all ages.

Illustrations. M.I.H. Brooker & D.A. Kleinig, *Field Guide Eucalypts* 2: 314 (1990); 2nd edn, 2: 314 (2001); 3rd edn, 2: 288 (2016); A.V. Slee *et al.*, *EUCLID Eucalypts of Australia* CD ROM, *Eucalyptus dissimulata* (2006); M.E. French, *Eucalypts W. Austral. Wheatbelt* 252, 253 (2012); M.E. French & D. Nicolle, *Eucalypts W. Austral. – S.W. Coast & Ranges* 210, 211 (2019).

Distribution and habitat. Endemic to W.A., where it is distributed in an area roughly bounded by Kondinin in the north, Borden in the south-west, and Ravensthorpe in the east (although not in the Ravensthorpe Range itself) (Fig. 38). It grows in mallee shrubland or mixed mallee woodland vegetation on mostly level topography in pale-coloured sand or loam overlying clay. Associated eucalypts include *Eucalyptus captiosa*, *E. ecostata*, *E. flocktoniae* subsp. *flocktoniae*, *E. incrassata s.lat.*, *E. leptocalyx* subsp. *leptocalyx*, *E. lunata*, *E. phaenophylla*, *E. pleurocarpa*, *E. scyphocalyx*, *E. sporadica*, *E. thamnoides*, *E. uncinata* subsp. *uncinata* and *E. xanthonema*.

Conservation status. The subspecies is not yet assessed under the IUCN Red List of Threatened Species (IUCN 2020). Considering its known distribution, life cycle, and threats, we believe that an IUCN Red List category of 'Near Threatened' is appropriate for the subspecies.

Not a listed taxon under Conservation Codes for Western Australian Flora (Smith & Jones 2018). Recorded from Fitzgerald River National Park and from Lake Magenta and Lakeland nature reserves.

Notes. *Eucalyptus dissimulata* subsp. *dissimulata* has consistently glossy, green adult leaves, which distinguishes the subspecies from the more easterly-distributed subsp. *plauta*. Its adult leaves also tend to be narrower than those of subsp. *plauta*.

Eucalyptus dissimulata subsp. *dissimulata* is associated with *E. lunata* south-west of Pingrup and with *E. albida* south of Hyden. Hybrids between these two species have not been recorded.

Selected specimens

WESTERN AUSTRALIA (west to east). Chester Pass Rd, S of Borden, 22 Nov. 2018, *M.E. French 3080* (PERTH); c. 7 km from Pingrup to Ongerup Rd on Rabbit Proof Fence Rd to SE, 26 Jan. 2001, *D. Nicolle 3744 & M.E. French* (PERTH); N of Rabbit Proof Fence Rd, NE of Ongerup, 22 Oct. 2014, *M.E. French 2749* (PERTH); Alan Rd, SE of Lake Grace, 21 Oct. 2014, *M.E. French 2743* (PERTH); Pelham Rd, SE of Lake Grace, 22 Feb. 2014, *M.E. French 2656* (PERTH); Pelham Rd, SE of Lake Grace, 21 Oct. 2014, *M.E. French 2744* (PERTH); c. 4 km N of railway at Burngup, 30 Nov 1984, *M.I.H. Brooker 8752* (CANB, PERTH); c. 20 km W of Jerramungup towards Ongerup, 9 Dec. 1992, *D. Nicolle 205* (AD); N of Needilup, 21 Jan. 1996, *D. Nicolle 1629* (PERTH); Stock Rd, SW of Jerramungup, 21 Oct. 2014, *M.E. French 2748* (PERTH); c. 11 km N of Reserve rd on Magenta rd, 14 Jan. 1985, *M.I.H. Brooker 8784* (CANB, PERTH); Mallee Rd, N of Reserve Rd, 23 Mar. 2010, *D. Nicolle 5506 & M.E. French* (PERTH); Old Ravensthorpe Rd (or Taylor Rd), c. 3 km W of gate to 'Nardoo', 4 Sep. 1999, *A.V. Slee 4195* (PERTH); West River crossing between Jerramungup and Ravensthorpe, 18 May 1987, *M.I.H. Brooker 9642* (CANB, PERTH); Hamersley Drive, SW of Ravensthorpe, Fitzgerald River N.P., 23 Mar. 2015, *M.E. French 2781* (PERTH); Hamersley Drive, Fitzgerald River N.P., 4 Nov. 2000, *D. Nicolle 3567 & M.E. French* (CANB, PERTH).

18b. *Eucalyptus dissimulata* subsp. *plauta* L.A.S.Johnson & K.D.Hill ex D.Nicolle & M.E.French, *subsp. nov.*

Holotypus: Western Australia, Coolgardie–Esperance Railway, c. 4 km S of Grass Patch, 18 Jan. 2021, *D. Nicolle 8008 & M.E. French* (PERTH). **Isotypi:** AD286728; CANB.

Eucalyptus sp. Truslove (*M.I.H. Brooker 7499*): D.Nicolle *et al.*, *Nuytsia* 22(3): 106 (2012).

This subspecies had previously been recognised under the designation *Eucalyptus dissimulata* 'subsp. plauta' (Johnson & Hill ms), but the name was never formally published.

Adult leaves (narrow-lanceolate to) lanceolate (to broad lanceolate), 50–110 mm long × 6–22 mm wide (length:width ratio 5–9:1), dull and blue-green initially, aging to glossy and dark green. **Fig. 41.**

Diagnostic characters. Distinguished from *E. dissimulata* subsp. *dissimulata* by its typically broader adult leaves which are dull and blue-green initially, typically giving the whole canopy a bluish sheen.

Distribution and habitat. Endemic to W.A., where it is restricted to the Grass Patch to Scaddan area on

Fig. 41. *Eucalyptus dissimulata* subsp. *plauta*. **A** habit; **B** bark; **C** foliage; **D** buds and flowers; **E** fruits. — A–C, E *D. Nicolle 8008 & M.E. French*, S of Grass Patch; D *D. Nicolle 8009 & M.E. French*, S of Grass Patch.

the plains north of Esperance (Fig. 38). It grows in mallee shrubland or mixed mallee woodland vegetation on level topography in whitish, sandy to loamy soils overlying clay and/or limestone. Associated eucalypts include *Eucalyptus connexa*, *E. cylindriflora*, *E. eremophila*, *E. forrestiana*, *E. leptocalyx* and *E. valens*.

Conservation status. Not yet assessed under the IUCN Red List of Threatened Species (IUCN 2020). Considering its known distribution, life cycle, and threats, we suggest an IUCN Red List category of 'Endangered' for the subspecies.

Not a listed taxon under Conservation Codes for Western Australian Flora (Smith & Jones 2018). The subspecies has a restricted distribution which is entirely within a highly agriculturally fragmented landscape, with all known populations occurring on narrow roadside or railway verges. It has not been recorded from any gazetted reserves. We recommend an interim code of EN (Endangered) using Conservation Codes for Western Australian Flora and Fauna criteria under the *Biodiversity Conservation Act 2016*.

The 2015 Esperance bushfires burnt vegetation where Ian Brooker collected several populations of the subspecies in the 1980s, in the southern part of its small distribution (*Brooker 7499*, *Brooker 8669*, *Brooker 9521*). Despite dedicated searches by us for these populations in January 2021, and the subspecies being a lignotuber resprouter, we were unable to relocate any of them. It is likely that these populations no longer exist, having been cleared by road and/or paddock widening in the last few decades.

Etymology. The epithet, coined by L.A.S. Johnson and K.D. Hill, is from the Latin *plautus* (wide or broad). The intended meaning of the name is not clear, but it is likely to refer to the relatively broad adult leaves of the subspecies compared to subsp. *dissimulata*.

Notes. *Eucalyptus dissimulata* subsp. *plauta* has adult leaves that are initially dull and bluish, which distinguishes it from the more westerly-distributed subsp. *dissimulata*. Its adult leaves also tend to be broader than those of subsp. *dissimulata*.

The distribution of *E. dissimulata* subsp. *plauta* appears to be isolated by about 140 km from that of subsp. *dissimulata*. Although no intermediates are known, we believe that subspecific status is appropriate because the morphological differences are slight.

Eucalyptus dissimulata subsp. *plauta* is associated with *E. connexa* on some sites. Hybrids between these two species have not been recorded.

Selected specimens

WESTERN AUSTRALIA (north to south). c. 7 km S of Salmon Gums, 22 Aug. 2006, *M.I.H. Brooker 9506* (AD, CANB, MEL, NSW, PERTH); E of Coolgardie-Esperance Hwy on Guests Rd, 12 Mar. 2004, *D. Nicolle 3897 & M.E. French* (CANB); Highway 1, c. 15 km S of silo at Salmon Gums, 8 Sep. 1999, *A.V. Slee 4221* (CANB); Rollond Rd, c. 2 km W of Coolgardie Esperance Hwy, 18 Jan. 2021, *D. Nicolle 8011 & M.E. French* (PERTH); E side of rail line in service tk, S of Grass Patch, 6 Dec. 2020, *M.E. French 3481* (PERTH); Coolgardie Esperance Railway, c. 4 km S of Grass Patch, 18 Jan. 2021, *D. Nicolle 8009 & M.E. French* (PERTH); W of hwy SW of Truslove (Hawkey rd), 7 Sep. 1984, *M.I.H. Brooker 8669* (PERTH, CANB); c. 7 km W of Hwy 1 on Briggs [Griggs] Rd, SW of Truslove, 2 May 1982, *M.I.H. Brooker 7499* (PERTH, CANB, NSW); c. 4 km W of Norwood rd on Kendall rd, 7 Nov. 1986, *M.I.H. Brooker 9521* (PERTH, CANB); between Gibsons Soak [Gibson] and Scaddan (*fide* A.V. Slee, 2 Nov. 2017, after viewing notebook), 1 Apr. 1968, *D.J. Carr & S.G.M. Carr 641* (CANB, MEL, NSW, PERTH).

19. *Eucalyptus discreta* Brooker

Brunonia 2(1): 148 (1979). — **Holotype:** 98 miles east of Esperance on the Fisheries road towards Balladonia, 9 Apr. 1974, *M.I.H. Brooker 4484* (CANB412294 [ex FRI]). **Isotypes:** AD97551397; MEL1616379; NSW350448; PERTH.

Mallee to 6 (rarely to 12) m tall; lignotuber present, lignotuber resprouter (Nicolle 2006). *Bark* usually smooth throughout, decorticating annually in strips, grey over cream, larger individuals sometimes with persistent bark up to 2 m, fibrous, grey, then smooth above. *Branchlets* non-pruinose. *Seedling leaves* opposite for 6–14 pairs then becoming disjunct, nodes 5–25 mm apart, sessile or on petioles to 1 mm long, linear to elliptic (typically narrowly elliptic), 10–50 (–95) mm long × 2–12 mm wide, length:width ratio typically 2–10 (–14):1, slightly discolorous, dull, green to blue-green, non-pruinose. *Coppice leaves* similar but generally larger, becoming disjunct. *Mature crown* composed entirely of adult leaves. *Adult leaves* with petioles 5–12 mm long, lamina narrow-lanceolate to lanceolate, 50–100 mm long × 5–12 mm wide, length:width ratio typically 6–12:1, dull and blue-green at first, maturing to be glossy and dark green, non-pruinose; tertiary venation moderate to dense; oil glands numerous, connected to vein network (intersectional oil glands). *Inflorescences* 7–9-flowered; peduncles angular, 3–12 mm long; pedicels 1–2.5 mm long. *Flower buds* clavate or ovoid, 5–7 mm long × 2.5–4 mm diam.; opercula hemispherical, 2–3 mm long, length:width ratio typically 0.5–1:1. *Fruits* cupular to shortly barrel-shaped, 4–6 mm long × 4–5.5 mm diam.; disc descending; valves 3 (4), at or below rim level.

Diagnostic characters. Distinguished within *E.* ser. *Porantherae* by the following combination of characters: Lignotuberous mallee. Bark usually smooth and shedding throughout. Branchlets non-pruinose. Seedling leaves opposite initially but soon becoming disjunct, well-spaced, linear to elliptic (length:width ratio 2–14:1), green to blue-green, non-pruinose (Fig. 42). Adult leaves narrow-lanceolate to lanceolate (length:width ratio 6–12:1), initially dull, blue-green maturing glossy, dark

green. Pedicels short. Opercula rounded, wider than long. Fruits shortly-barrel-shaped.

Illustrations. M.I.H. Brooker & D.A. Kleinig, *Field Guide Eucalypts* 2: 311 (1990); 2nd edn, 2: 311 (2001); 3rd edn, 2: 285 (2016).

Distribution and habitat. Endemic to W.A., occurring from the Speddingup area north of Esperance eastwards to near Israelite Bay, inland to the Splinters Rock area (Fig. 43). It occurs in a variety of habitats, typically on plains of calcareous pale red to whitish loams or whitish sand overlying limestone, but also on broad rises with outcropping granite (e.g. Howick Hill). It grows as a component of mallee shrubland. Associated eucalypts include *Eucalyptus conglobata* subsp. *conglobata*, *E. cooperiana*, *E. eremophila*, *E. extrica*, *E. flocktoniae* subsp. *hebes*, *E. incrassata s.lat.*, *E. leptocalyx*, *E. luculenta*, *E. micranthera*, *E. oleosa* subsp. *ampliata*, *E. tetraptera* and *E. tumida*.

Conservation status. Globally listed as 'Near Threatened' on the IUCN Red List of Threatened Species (IUCN 2020). This assessment included *E. sinuensis* K.D.Hill & L.A.S.Johnson ex D.Nicolle & M.E.French in *E. discreta* at that time, but nonetheless 'Near Threatened' remains an appropriate listing for *E. discreta* with the exclusion of *E. sinuensis*.

Not a listed taxon under Conservation Codes for Western Australian Flora (Smith & Jones 2018). Recorded from Nuytsland Nature Reserve and Cape Arid National Park.

Common names. Mount Ragged Mallee (Brooker & Kleinig 2016).

Fig. 42. *Eucalyptus discreta* seedlings. **A** F1 of *D. Nicolle 1091*, Mt Ragged to Israelite Bay track, W.A.; **B** F1 of *M.D. Crisp 4854*, S of Tower Peak, W.A.; **C** F1 of *D. Nicolle 7726*, Howick Rd, at high point near Mt Howick, W.A.; **D** F1 of *M.E. French 2923*, Parmango Rd, NE of Condingup, W.A.

Notes. With the description of the more-easterly distributed *E. sinuensis*, the circumscription of *E. discreta* is restricted to mallees on the plains north and east of Esperance. *Eucalyptus sinuensis* differs from *E. discreta* by the consistently non-shedding bark on its lower trunks, its broader juvenile leaves that become disjunct later, and its longer buds with longer, conical to slightly beaked opercula.

Eucalyptus connexa (another *E.* ser. *Porantherae* species) occurs within part of the distribution of *E. discreta*, although the two species are not known to occur together. *Eucalyptus connexa* is easily distinguished from *E. discreta* by its often conspicuous juvenile leaves, which are large, rounded and always connate, and by its sessile buds and fruits.

Selected specimens

WESTERN AUSTRALIA (west to east). Scaddan Rd, c. 4 km NW from Dempster Rd, 12 Sep. 1999, *A. Slee 4238* (CANB); Mt Ney road SW of Mt Ney, 10 Apr. 1985, *M.I.H. Brooker 8927* (CANB, PERTH); Parmango Rd, N of Beaumont grain bin, NE of Condingup, 11 Dec. 2016, *M.E. French 2923* (PERTH); Howick Rd, near Mt Howick, 14 Oct. 2019, *D. Nicolle 7726* (PERTH); c. 16 km due SSW of Clyde Hill on Shearer Rd, 3 May 1983, *M.A. Burgman & S. McNee 1168* (PERTH); c. 22 km from Parmango Rd on Buraminya tk to Mt Ney Rd, 7 Nov. 2000, *D. Nicolle 3613 & M.E. French* (CANB, PERTH); W of Parmango Rd on tk heading due W to N end of Mt Ney tk, 17 Jan. 2021, *D. Nicolle 7998 & M.E. French* (PERTH); W of Parmango Rd on tk heading due W to N end of Mt Ney tk, 17 Jan. 2021, *D. Nicolle 7996 & M.E. French* (PERTH); c. 123 km S of Balladonia, SW of Mt Ragged, 3 Apr. 1977, *M.I.H. Brooker 5634* (AD, CANB, MEL, PERTH); c. 128 km S of Balladonia roadhouse on tk to Mt Ragged, 20 Oct. 1983, *K.D. Hill 246 & L.A.S. Johnson* (NSW, PERTH); c. 2 km S of Mt Ragged (Tower Peak) Ra. along road to Israelite Bay, 6 Jan. 1979, *M.D. Crisp 4854* (CANB, NSW, PERTH); Mt Ragged to Israelite Bay tk, 21 Nov. 1994, *D. Nicolle 1091* (AD, CANB, PERTH); c. 8 km from Israelite Bay tk on Mt Ragged tk, 8 Apr. 1985, *M.I.H. Brooker 8915* (CANB, PERTH).

20. *Eucalyptus sinuensis* K.D.Hill & L.A.S.Johnson ex D.Nicolle & M.E.French, *sp. nov.*

Holotypus: Western Australia, 18 km S of Madura Pass on 'beach road', 25 Oct. 2000, *A.V. Slee 4271 & J.R. Connors* (PERTH05998379). **Isotypi:** AD112792; CANB530744; NSW503754.

Eucalyptus sp. Eyre (*K. Hill & L.A.S. Johnson KH 2170*): D.Nicolle *et al.*, *Nuytsia* 22(3): 96 (2012).

Eucalyptus sp. Madura Beach (*D. Nicolle 1570*): D.Nicolle *et al.*, *Nuytsia* 22(3): 97 (2012).

This species had previously been recognised under the designation *Eucalyptus* 'sinuensis' (Hill & Johnson ms), but a name was never formally published.

Mallee to 6 m tall; lignotuber present, lignotuber resprouter (Nicolle 2006). *Bark* persistent on lower trunks to most of trunks (up to 1–3 m from base), tightly-held, stringy-fibrous, then smooth above, tan and grey, decorticating annually in strips. *Branchlets* non-pruinose. *Seedling leaves* opposite for 12–18+ pairs then becoming disjunct, nodes 10–26 mm apart, sessile or on petioles to 1 mm long, oblong or narrowly elliptic to ovate or cordate (typically elliptic), 17–40 mm long × 4–22 mm wide, length:width ratio typically 1.5–3.5:1, slightly discolorous, dull, green, non-pruinose. *Coppice leaves* similar but generally larger, becoming disjunct. *Mature crown* composed entirely of adult leaves. *Adult leaves* with petioles 5–12 mm long, lamina

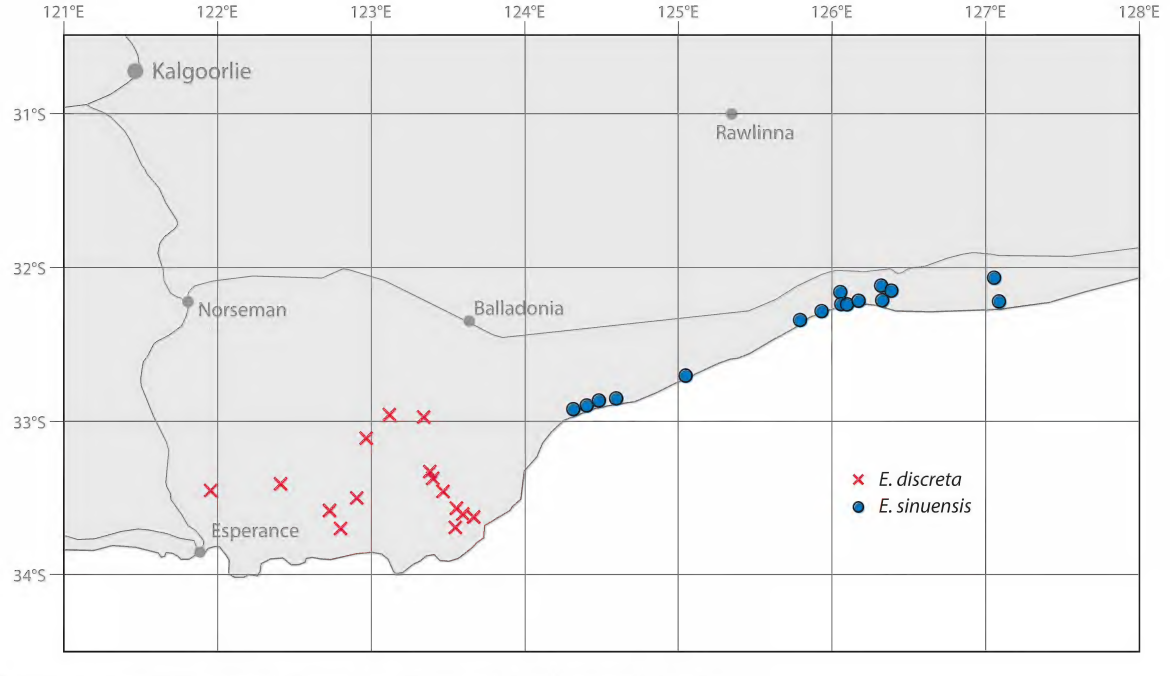

Fig. 43. Distribution of *Eucalyptus discreta* and *E. sinuensis* in Western Australia.

(narrow-lanceolate to) lanceolate, 50–90 mm long × 5–12 mm wide, length:width ratio typically 6.5–10:1, dull to glossy and slightly blue-green at first, maturing glossy and dark green, non-pruinose; tertiary venation moderate to dense; oil glands numerous, connected to vein network (intersectional oil glands). *Inflorescences* 7–9-flowered; peduncles angular, 4–10 mm long; pedicels 1–4 mm long. *Flower buds* fusiform, 6–10 mm long × 2–3 mm diam.; opercula conical to slightly beaked, 2.5–5 mm long, length:width ratio typically 1.5–2:1. *Fruits* cupular to barrel-shaped, 4.5–5 mm long × 4–5 mm diam.; disc descending; valves 3 (4), below rim level. **Fig. 44.**

Diagnostic characters. Distinguished within *E.* ser. *Porantherae* by the following combination of characters: Lignotuberous mallee. Bark persistent (non-shedding) on lower trunks. Branchlets non-pruinose. Seedling leaves opposite for many pairs then becoming disjunct, well-spaced, typically elliptic (length:width ratio

Fig. 44. *Eucalyptus sinuensis*. **A** *D. Nicolle 7973*, Eyre Bird Observatory; **B** unvouchered, track to Madura Beach.

Fig. 45. *Eucalyptus sinuensis* seedlings. **A** F1 of *D. Nicolle 1081*, track to Madura Beach, W.A.; **B** F1 of *D. Nicolle 5993 & M.E. French*, N of Bilbunya Dunes, W.A.

1.5–3.5:1), green, non-pruinose (Fig. 45). Adult leaves narrow-lanceolate to lanceolate (length:width ratio 6.5–10:1), dull to glossy and slightly blue-green at first, maturing glossy and dark green. Pedicels short. Opercula conical to slightly beaked. Fruits cupular to barrel-shaped.

Distribution and habitat. Endemic to W.A., where it occurs from the Wylie Scarp south-east of Balladonia eastwards along the coast to the Roe Plains south of Madura (Fig. 43). The species grows on whitish sand overlying limestone, both above and below the limestone scarp (where the scarp is inland of the coastline). It is restricted to the dune systems and associated sandplains, and does not extend far inland, except where the limestone plain is overlaid with sand, such as on the Roe Plain where it extends to about 30 km from the coast. It grows as a component of mallee shrubland with *Callitris verrucosa* and numerous associated eucalypts including *Eucalyptus brachycalyx*, *E. calcareana*, *E. conglobata* subsp. *conglobata*, *E. cooperiana*, *E. diversifolia* subsp. *hesperia*, *E.* aff. *eremophila*, *E. gracilis*, *E. incrassata*, *E. oleosa* subsp. *ampliata*, *E. scyphocalyx s.str.* and *E. yalatensis*. *Triodia* is often present within the ground-storey vegetation.

Conservation status. Not yet assessed under the IUCN Red List of Threatened Species (IUCN 2020). Considering its known distribution, life cycle, and threats, we believe that an IUCN Red List category of 'Least Concern' is appropriate for the species.

Not a listed taxon under Conservation Codes for Western Australian Flora (Smith & Jones 2018). Most populations occur in Nuytsland Nature Reserve.

Etymology. The epithet, first coined by K.D. Hill & L.A.S. Johnson, is from the Latin *sinus* (a bend, curve, bay) and the suffix *-ensis* (pertaining to), referring to its distribution on the Great Australian Bight.

Common names. None known. We suggest the common name 'Nuytsland Mallee'.

Notes. One of the most common mallees on the dune systems along the coast on the western half of the Great Australian Bight. It was previously included in a broader concept of *E. discreta* and is distinguished from that species by its consistently non-shedding bark on the lower trunks, its broader seedling leaves that become disjunct later, and its longer buds with longer, conical to slightly beaked opercula. No other taxa of *E.* ser. *Porantherae* occur within the distribution of *E. sinuensis*.

Selected specimens

WESTERN AUSTRALIA (west to east). Top of escarpment to N of Telegraph tk, N of Bilbunya Dunes, 6 Apr. 2011, *D. Nicolle 5993 & M.E. French* (PERTH); Toolinna Cove, 7 Oct. 1993, *D. Nicolle 557* (PERTH); 19 km S of Cocklebiddy on the Twilight Cove Rd, 13 Feb. 2005, *L. Sweedman 6522* (PERTH); Kanidal Beach, 3 Apr. 2011, *D. Nicolle 5969 & M.E. French* (PERTH); 1.2 km N of Eyre Bird Observatory, 12 July 1983, *S.D. Hopper 2976* (PERTH); 14.4 km on tk from Eyre Hwy to Eyre Bird Observatory, 16 Dec. 2000, *M.E. French 1249* (PERTH); c. 1 km N of Eyre Bird Observatory on tk to Eyre Hwy, Nuytsland N.R., 15 Jan. 2021, *D. Nicolle 7973* (AD, CANB, PERTH); Wurrengoodya Hills, tk to Eyre Bird Observatory from hwy, 3 Apr. 2011, *D. Nicolle 5967 & M.E. French* (PERTH); S of Eyre Hwy towards Eyre Bird Observatory, 5 Oct. 1996, *D. Nicolle 1814* (CANB, PERTH); c. 17 km S of Madura Pass, 26 July 1999, *J.R. Connors 1073 & D. Nicolle* (CANB, NSW, PERTH); tk to Madura Beach, 19 Nov. 1994, *D. Nicolle 1081* (AD 162726, CANB, PERTH); rd to Madura Beach, S of Madura, 25 Sep. 2015, *M.E. French 2802* (PERTH).

21. *Eucalyptus uncinata* Turcz.

Bull. Soc. Imp. Naturalistes Moscou 22(3): 23 (1849). — **Type citation:** "Drum. III. n. 66". **Holotype:** Nova Hollandia [Swan River, 1845,] *J. Drummond 66 (3rd collection)* (KW001001338). **Isotypes:** BM001015306; CANB; F, FI, K, LE, MEL, NSW, P, W, *n.v.*, *fide* Brooker, *Brunonia* 2: 131 (1979).

Eucalyptus dumosa var. *puncticulata* Benth., *Fl. Austral.* 3: 230 (1867); *Eucalyptus puncticulata* (Benth.) Blakely, *Key Eucalypts* 114 (1934). — **Type citation:** "W. Australia, from Gordon river, *Oldfield*, to Mount Barren Ranges, *Maxwell*". **Lectotype (here designated):** Stony Hills, Gordon River, W.A., *A. Oldfield s.n.* (K00347540).

Eucalyptus uncinata var. *latifolia* Benth., *Fl. Austral.* 3: 216 (1867). — **Type citation:** "W. Australia, *Drummond*, *4th coll. n.* 76." **First-step lectotype:** "Swan River Colony, W.A., 1848, *J. Drummond 4: 76*" (K), *fide* Chippend., *Fl. Australia* 19: 283 (1988), as "holo". **Second-step lectotype (here designated):** "Sw. ri. to Ki. G. S." [Swan River to King Georges Sound], 1848, *J. Drummond* [*4:*] *76* (K000347535). **Isolectotypes:** BM001015307; FI011466; K000347536; KW 001001337; LE00015404; MEL1616395; NSW 350692; P01902183; P01902184; PERTH01395092; CGE, *n.v.*

Mallee to 8 m tall; lignotuber present, lignotuber resprouter (Nicolle 2006). *Bark* sometimes persistent on lower trunks up to 2 m, flaky-fibrous, grey, then smooth above or often smooth throughout, decorticating annually in strips, grey to tan over cream. *Branchlets* non-pruinose. *Seedling leaves* opposite for 13–18+ pairs, on nodes 10–40 mm apart, sessile, sometimes connate, orbicular to cordate to ovate, 12–30 mm long × 12–30 mm wide, length:width ratio typically 0.6–1.4:1, somewhat discolorous, dull, green to grey-green, sometimes pruinose. *Coppice leaves* similar but typically larger and more spaced. *Mature crown* composed entirely of adult leaves. *Adult leaves* with petioles 5–20 mm long, lamina narrow-lanceolate to broad-lanceolate, 45–110 mm long × 5–24 mm wide, length:width ratio typically 4–9.5:1, glossy, light green to dark green (rarely initially dull and blue-green), non-pruinose; tertiary venation dense; oil glands numerous, connected to vein network (intersectional oil glands). *Inflorescences* 7–11-flowered; peduncles terete to angular to distinctly flattened and broadening distally, 3.5–20 mm long; pedicels absent or rarely to 1.5 mm long. *Flower buds* fusiform, clavate, diamond-shaped or ovoid, 6–13 mm long × 2–5 mm diam.; opercula conical to bluntly conical, 2.5–6 mm long, length:width ratio typically 0.8–1.3:1. *Fruits* truncate-globose to cupular to barrel-shaped, 6–7.5 mm long × 5–8.5 mm diam.; disc descending; valves 3 (4), at rim level or below.

Diagnostic characters. Distinguished within *E.* ser. *Porantherae* by the following combination of characters: Lignotuberous mallee. Bark persistent on lower trunks or smooth throughout. Branchlets non-pruinose. Seedling leaves opposite, sometimes connate, orbicular to cordate to ovate (length:width ratio 0.6–1.4:1), sometimes pruinose (Fig. 46). Adult leaves narrow-lanceolate to broad-lanceolate (length:width ratio 4–9.5:1), maturing glossy and green. Pedicels absent or very short. Opercula conical to bluntly conical. Fruits truncate-globose to cupular to barrel-shaped.

Distribution and habitat. Endemic to W.A., where it is widespread and quite common near the south coast, from near Lake Muir eastwards to Point Culver, and inland to west of Quairading, near Lake King and Peak Charles, with a more strictly coastal distribution in the eastern part of its range between Esperance and Point Culver, only extending inland to major hills such as the Russell Range (further inland being replaced by the related *E. connexa*) (Fig. 47). It grows in a variety of habitats, but typically on undulating to hilly sites in gravelly clay or loam derived from laterite, but also on paler-coloured sandier soils on plains. It occurs as a component of mallee shrubland or in mallee woodland with numerous other eucalypt species.

Conservation status. Globally listed as 'Vulnerable' on the IUCN Red List of Threatened Species (IUCN 2020). This assessment included *E. connexa* in *E. uncinata* at that time. We do not agree with this assessment, as *E. uncinata* is one of the most commonly-encountered species within its relatively large distribution and is well represented in numerous reserves. Considering its known distribution, life cycle, and threats, we believe that an IUCN Red List category of 'Least Concern' is more appropriate for the species.

Eucalyptus uncinata is not currently listed under Conservation Codes for Western Australian Flora (Smith & Jones 2018).

We below suggest conservation codes for the two subspecies of *E. uncinata* using IUCN and Conservation Codes for Western Australian Flora assessment methodology.

Common names. Hook-leaved Mallee (Chippendale 1988; Brooker & Kleinig 2016; French & Nicolle 2019), Hooked-leaved Mallee (French 2012).

Notes. *Eucalyptus uncinata* is a variable but generally distinctive species, characterised within *E.* ser. *Porantherae* by its well-spaced, variably connate, orbicular to cordate seedling leaves and its sessile or near-sessile buds and fruits. There is much variability in the connation of the paired seedling leaves between populations, with only about 30% of the populations we have sampled or grown having connate seedling leaves.

The circumscription of *E. uncinata* is here modified due to the description of *E. connexa* to accommodate populations from the plains north and north-east of Esperance. *Eucalyptus connexa* was previously included in *E. uncinata*, but differs in more spaced, larger, more pointed and consistently connate seedling leaves, its initially dull and bluish adult leaves, its generally

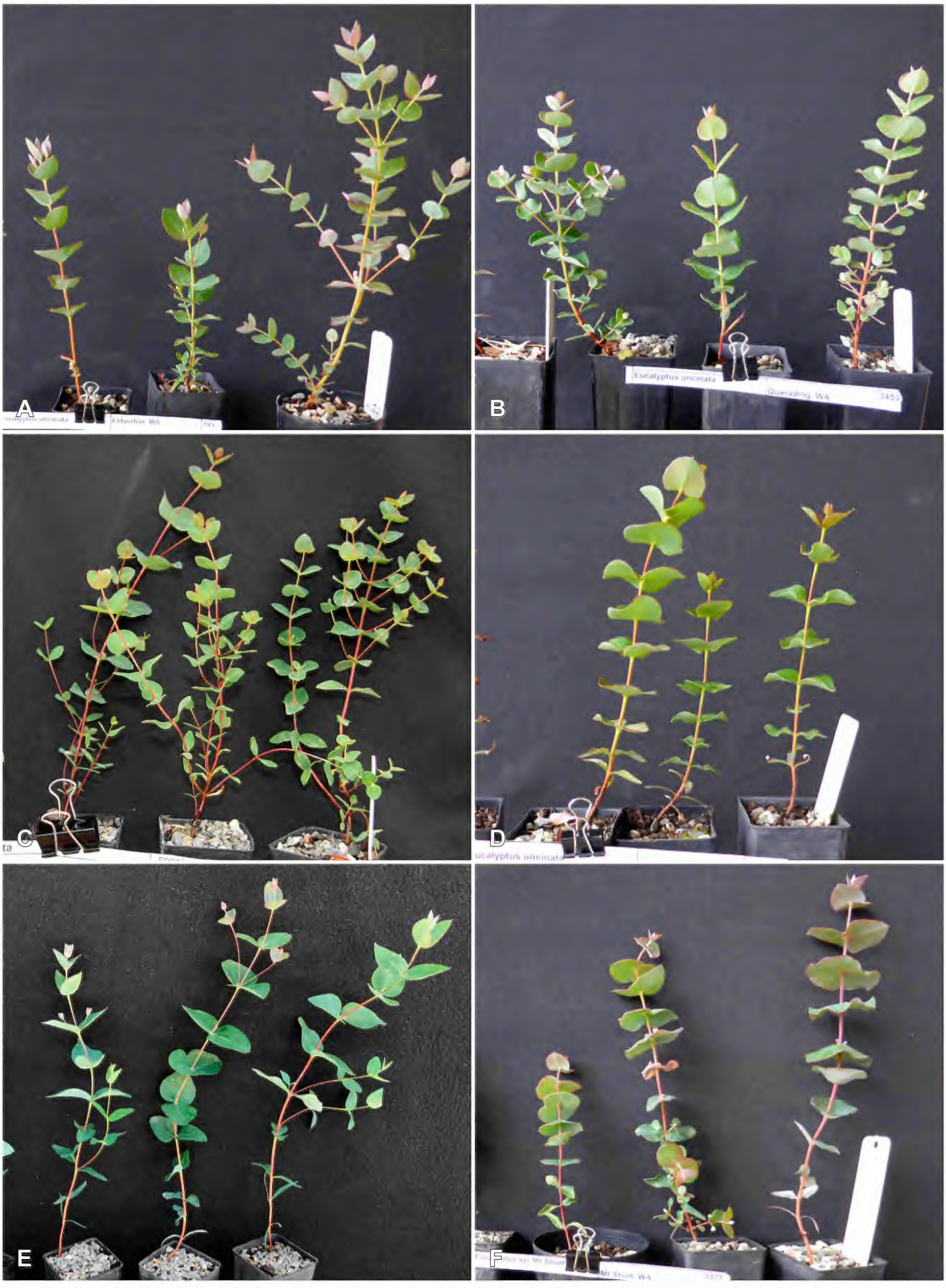

Fig. 46. *Eucalyptus uncinata* seedlings. **A** subsp. *uncinata*, F1 of *D. Nicolle 195*, S of Eldverton towards Hopetoun, W.A.; **B** subsp. *uncinata*, F1 of *D. Nicolle 3453 & M.E. French*, N from Quairading-York Rd, W.A.; **C** subsp. *uncinata*, F1 of *D. Nicolle 5992 & M.E. French*, Telegraph track, just below Wylie Scarp, W.A.; **D** subsp. *uncinata*, F1 of *M.E. French 2788*, Unicup N.R., W.A.; **E** subsp. *uncinata*, F1 of *D. Nicolle 7748*, Kundip N.R., W.A.; **F** subsp. *crassa*, F1 of *D. Nicolle 3575 & M.E. French*, near Mt Short, N of Ravensthorpe, W.A.

smaller buds with shorter opercula, and its generally smaller, more globose to somewhat urceolate fruits with a smaller orifice. It also tends to be larger-growing, often reaching tree proportions, and typically has persistent, rough bark on the trunks. The habitat of *E. connexa* also differs somewhat from that of *E. uncinata*, being restricted to plains and depressions in limestone-derived soils, often fringing salt lakes.

Two subspecies are recognised in *E. uncinata*, differing in the width, thickness and colour of their adult leaves, the length and thickness of their peduncles and the size of their buds, and to a lesser extent in the size of their seedling leaves and fruits.

21a. *Eucalyptus uncinata* Turcz. subsp. *uncinata*

Adult leaves 7–20 mm wide (length:width ratio 4–9.5:1), <1 mm thick, green to dark green. *Inflorescence* peduncles terete to angular to slightly flattened, 3.5–11 mm long. *Flower buds* 6–9 mm long.

Diagnostic characters. Distinguished from *E. uncinata* subsp. *crassifolia* by its thinner (less firm), darker green and generally narrower adult leaves, its less flattened and distally broadening, generally shorter peduncles, and its smaller buds. The seedling leaves and fruits also tend to be smaller than in subsp. *crassifolia*.

Illustrations. M.E. French, *Eucalypts W. Austral. Wheatbelt* 264, 265 (2012); M.E. French & D. Nicolle, *Eucalypts W. Austral. – S.W. Coast & Ranges* 221 (2019).

Distribution and habitat. Endemic to W.A., where it is widespread and quite common near the south coast, from near Lake Muir westwards to Point Culver, and inland to west of Quairading and near Lake King, with a more strictly coastal distribution in the eastern part of its range between Esperance and Point Culver, only extending inland to major hills such as the Russell Range (Fig. 47). It grows in a variety of habitats, but typically on undulating to hilly sites in gravelly clay or loam derived from laterite, but also on paler-coloured sandier soils on plains. It occurs as a component of mallee shrubland or in mallee woodland with numerous other eucalypt species. Commonly associated eucalypts include *Eucalyptus adesmophloia*, *E. angulosa*, *E. astringens*, *E. calycogona* subsp. *calycogona*, *E. conglobata*, *E. decurva*, *E. dissimulata*, *E. ecostata*, *E. flocktoniae* subsp. *flocktoniae*, *E. hebetifolia*, *E. incrassata*, *E. lehmannii*, *E. leptocalyx*, *E. micranthera*, *E. occidentalis*, *E. pachyloma*, *E. phaenophylla*, *E. pileata*, *E. pleurocarpa*, *E. preissiana*, *E. redunca*, *E. sporadica*, *E. semiglobosa*, *E. suggrandis*, *E. tetraptera*, *E. thamnoides*, *E. vegrandis*, *E. wandoo* subsp. *wandoo* and *E. xanthonema*.

Conservation status. The subspecies is not yet assessed under the IUCN Red List of Threatened Species (IUCN 2020). Considering its known distribution, life cycle, and threats, we believe that an IUCN Red List category of 'Least Concern' is appropriate for the subspecies.

Not a listed taxon under Conservation Codes for Western Australian Flora (Smith & Jones 2018). The species is one of the most common in its area of occurrence. It is recorded from Cape Arid, Cape Le Grand, Fitzgerald River, Stirling Range and Stokes national parks, from Camel Lake, Corackerup, Johns Well, Kundip, Lake Magenta, Maublarling, Nuytsland, Penuip, Tarin Rock, Silver Wattle Hill, Unicup and Weam nature reserves, and from Dryandra Forest Reserve.

Notes. One of the most commonly encountered eucalypt species in the southern coastal and subcoastal mallee shrublands. Many much rarer species are associated with *E. uncinata*, due to its commonness and the variety of habitats in which it grows.

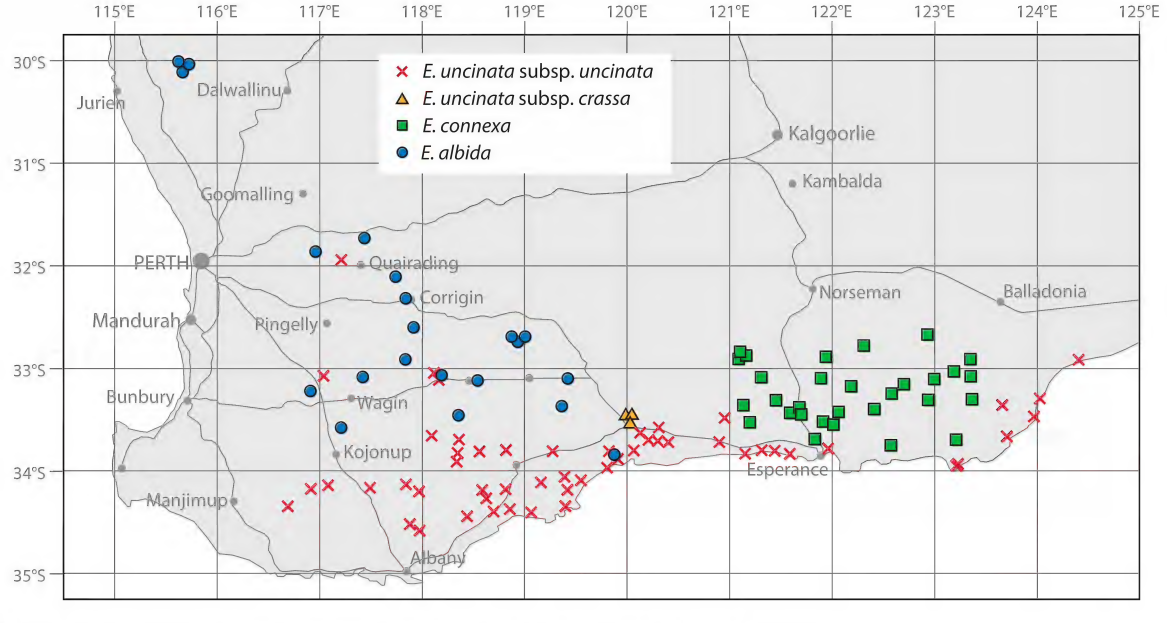

Fig. 47. Distribution of *Eucalyptus uncinata*, *E. connexa* and *E. albida* in Western Australia.

Selected specimens

WESTERN AUSTRALIA (west to east). Unicup N.R., W of Frankland, 30 June 2015, *M.E. French 2788* (PERTH); Wandoora Rd, NW of Frankland, 27 Feb. 2014, *M.E. French 2660* (PERTH); 4.6 km N from Quairading-York Rd, 17 Sep. 2000, *D. Nicolle 3453 & M.E. French* (AD, CANB, PERTH); c. 2 km from Nunijup on Koonjie [Koonji] rd, 13 Nov. 1986, *K.D. Hill 2452, L.A.S. Johnson & D.F. Blaxell* (NSW, PERTH); Kamballup N.R., NE of Mount Barker, 9 July 2018, *M.E. French 3032* (PERTH); Tarin Rock Rd, at edge of N.R., 29 Apr. 1999, *A.V. Slee 4085* (CANB, PERTH); 1.7 km S of Beetle Rock rd towards Souness block, N of Stirling Ra., 7 Oct. 1982, *M.I.H. Brooker 7698* (CANB, PERTH); 0.5 km W of Mundarabin Bin on Tie Line Rd, 3 Nov. 2000, *A.V. Slee 4330 & J. Connors* (CANB, PERTH); 9.6 km from Eldverton towards Hopetoun, 9 Dec. 1992, *D. Nicolle 195* (AD); Jerdacuttup North Rd, ESE of Hopetoun-Ravensthorpe Rd, Kundip N.R., 18 Oct. 2019, *D. Nicolle 7748* (PERTH); 25 km E of Ravensthorpe on Esperance rd, then 2.5 km N of Nindibillup Rd, Eyre District, 13 Sep. 1999, *A.V. Slee 4246* (AD, CANB, PERTH); limestone bluffs to E of Stokes Inlet, 20 Jan. 2001, *D. Nicolle 3708 & M.E. French* (AD, CANB, PERTH); mid slope on Peak Charles NW of Salmon Gums, 4 Mar. 2008, *M.E. French 2046* (PERTH); 3.7 km along track W of Quagi Beach, 25 Nov. 1991, *M.I.H. Brooker 10913* (AD, CANB, NSW, PERTH); 9.2 km S along Farrell's Rd from Hwy towards Quagi Beach, 25 Nov. 1991, *M.I.H. Brooker 10912* (AD, CANB, PERTH); W slope of hill at NE end of Russell Ra., 1 May 2012, *D. Nicolle 6350 & M.E. French* (PERTH); Telegraph tk, just below Wylie Scarp, 6 Apr. 2011, *D. Nicolle 5992 & M.E. French* (AD, PERTH).

21b. *Eucalyptus uncinata* subsp. *crassifolia* D.Nicolle & M.E.French, *subsp. nov.*

Holotypus: Western Australia, S boundary Overshot Hill Nature Reserve, Ravensthorpe Range, 23 Mar. 2010, *D. Nicolle 5501 & M.E. French* (PERTH 08299250). **Isotypi:** AD, CANB.

Eucalyptus sp. Mt Short (*D. Nicolle & M. French DN 3575*): D.Nicolle *et al.*, *Nuytsia* 22(3): 107 (2012).

Adult leaves 8–24 mm wide (length:width ratio 4–7:1), to 1.5 mm thick, light green. *Inflorescence* peduncles flattened and distally widening, (5–) 10–20 mm long. *Flower buds* 8–13 mm long. **Fig. 48.**

Diagnostic characters. Distinguished from *E. uncinata* subsp. *uncinata* by its thicker (firmer) and generally broader adult leaves, its more flattened and distally broadening, generally longer peduncles, and its larger buds. The seedling leaves and fruits also tend to be larger than in subsp. *uncinata*.

Illustrations. M.E. French & D. Nicolle, *Eucalypts W. Austral. – S.W. Coast & Ranges* 220 (2019).

Distribution and habitat. Endemic to W.A., where it is restricted to the northern part of the Ravensthorpe Range, in the vicinity of Mt Short southwards to Overshot Hill, over a linear range of approximately 10 km (Fig. 47). It grows on the slopes and tops of locally-high, broad hills and rises in red to orange gravelly or sandy clay of lateritic origin, in mallee shrubland with many other eucalypt species. Associated eucalypts include *Eucalyptus clivicola*, *E. ecostata*, *E. incrassata*, *E. lehmannii* subsp. *parallela*, *E. phaenophylla*, *E. pleurocarpa* and *E. ravensthorpensis*.

Conservation status. Not yet assessed under the IUCN Red List of Threatened Species (IUCN 2020). Considering its known distribution, life cycle, and threats, we suggest an IUCN Red List category of 'Endangered' for the subspecies.

Not currently a listed taxon under Conservation Codes for Western Australian Flora (Smith & Jones 2018). Recorded from Overshot Hill Nature Reserve. We recommend that the conservation status of this subspecies be assessed in Western Australia, and recommend an interim code of VU (Vulnerable) using Conservation Codes for Western Australian Flora and Fauna criteria under the *Biodiversity Conservation Act 2016*.

Etymology. The epithet is from the Latin *crassus* (thick) and *folia* (leaf), referring to its distinctively thickened leaves compared to subsp. *uncinata*.

Notes. *Eucalyptus uncinata* subsp. *crassifolia* is a localised, morphologically extreme variant of the species, differing from the typical subspecies most notably in its very coarse features. It is restricted to the northern part of the Ravensthorpe Range, while subsp. *uncinata* occurs elsewhere in the area, including on the surrounding plains and in the central to southern parts of the Ravensthorpe Range.

Locally coarse-leaved populations and individuals of *Eucalyptus uncinata* occur on some coastal and near-coastal sites, such as at Quagi Beach and near Fitzgerald Inlet. Coastal populations of many eucalypt species have coarser leaves, buds and fruits compared to populations occurring further inland. We include near-coastal, locally coarse-leaved populations of *E. uncinata* in subsp. *uncinata*, as they do not form geographically discrete populations nor are they as morphologically distinctive and uniform as the inland-occurring subsp. *crassifolia*. *Eucalyptus uncinata* subsp. *crassifolia* can be distinguished from near-coastal, locally coarse-leaved populations of subsp. *uncinata* by its lighter green adult leaves, its longer, distinctly flattened and distally broadening peduncles, and its longer buds.

Selected specimens

WESTERN AUSTRALIA (west to east). Mt Short, Ravensthorpe Ra., 23 Mar. 2010, *D. Nicolle 5500 & M.E. French* (PERTH); Overshot Hill, W of Ravensthorpe Ra., c. 6 km NNW of Ravensthorpe, 2 Nov. 2008, *A. Markey 7085* (MEL, PERTH); near Mt Short, N of Ravensthorpe, 5 Nov. 2000, *D. Nicolle 3575 & M.E. French* (CANB, PERTH); King Rd, Ravensthorpe Ra., 23 Mar. 2010, *D. Nicolle 5499 & M.E. French* (CANB, PERTH); Floater Rd, Ravensthorpe Ra., 23 Mar. 2010, *D. Nicolle 5498 & M.E.*

Fig. 48. *Eucalyptus uncinata* subsp. *crassifolia*. **A** habit (*D. Nicolle 5501 & M.E. French*, Overshot Hill N.R., W.A.); **B** leaves, buds and flowers (F1 of *D. Nicolle 3575 & M.E. French*, Mt Short, W.A.); **C** fruits (F1 of *D. Nicolle 3575 & M.E. French*, Mt Short, W.A.).

French (PERTH); N of Fletcher Rd, c. 1 km W of Range Junction N of Ravensthorpe, 26 Oct. 1987, *K.L. Bradby KLB79* (PERTH); SE of Mt Short, N of Ravensthorpe, 18 Jan. 1985, *M.I.H. Brooker 8806* (AD, CANB, PERTH).

22. *Eucalyptus connexa* D.Nicolle & M.E.French, *sp. nov.*

Holotypus: Western Australia, c. 3 km N of Mt Andrew on track to Optus telegraph track, 16 Jan. 2021, *D. Nicolle 7989 & M.E. French* (PERTH). **Isotypi:** AD286727; CANB.

Tree or mallee to 10 m tall; lignotuber present, lignotuber resprouter (Nicolle 2006). *Bark* typically persistent on trunks up to 3 m, flaky-fibrous, grey, then smooth above (or completely smooth in smaller individuals), decorticating annually in strips, pale grey to tan over cream. *Branchlets* non-pruinose. *Seedling leaves* opposite for numerous pairs, on nodes 15–46 mm apart, sessile, connate, orbicular to cordate, 12–36 mm long × 12–38 mm wide, length:width ratio typically 0.6–1:1, slightly discolorous, dull, green to blue-green, sometimes pruinose on new growth. *Coppice leaves* similar but typically larger and more spaced. *Mature crown* composed entirely of adult leaves. *Adult leaves* with petioles 5–20 mm long, lamina narrow-lanceolate to lanceolate (rarely to broad-lanceolate), 38–100 mm long × 7–16 (–20) mm wide, length:width ratio typically 4–12:1, initially dull and blue-green, aging to be glossy and olive-green, non-pruinose; tertiary venation dense; oil glands numerous, connected to vein network (intersectional oil glands). *Inflorescences* 7–11-flowered; peduncles angular, 3–15 mm long; pedicels absent or rarely to 1 mm long. *Flower buds* fusiform, clavate or ovoid, 5–9 mm long × 2–3.5 mm diam.; opercula hemispherical to conical, 1.5–3.5 mm long, length:width ratio typically 0.5–1.3:1. *Fruits* truncate-globose to barrel-shaped to slightly urceolate, 3.5–6 mm long × 3–5 mm diam., orifice small; disc descending; valves 3, below rim level. **Fig. 49.**

Diagnostic characters. Distinguished within *E.* ser. *Porantherae* by the following combination of characters: Lignotuberous mallee or tree. Bark typically persistent on lower trunks. Branchlets non-pruinose. Seedling leaves opposite, consistently connate, orbicular to cordate (length:width ratio 0.6–1:1), usually non-pruinose (Fig. 50). Adult leaves narrow-lanceolate to lanceolate (rarely to broad-lanceolate) (length:width ratio 4–12:1), dull and blue-green initially, aging to glossy and olive-green. Pedicels absent or to 1 mm long. Opercula near-hemispherical to conical. Fruits small, truncate-globose to cupular to barrel-shaped, with a small orifice.

Fig. 49. *Eucalyptus connexa* habit and bark. **A, B** *D. Nicolle 8005 & M.E. French*, Mt Ney track, W.A.; **C, D** *D. Nicolle 8012 & M.E. French*, Rollond Rd, E of Grass Patch, W.A.; **E, F** unvouchered, Salmon Gums, W.A.

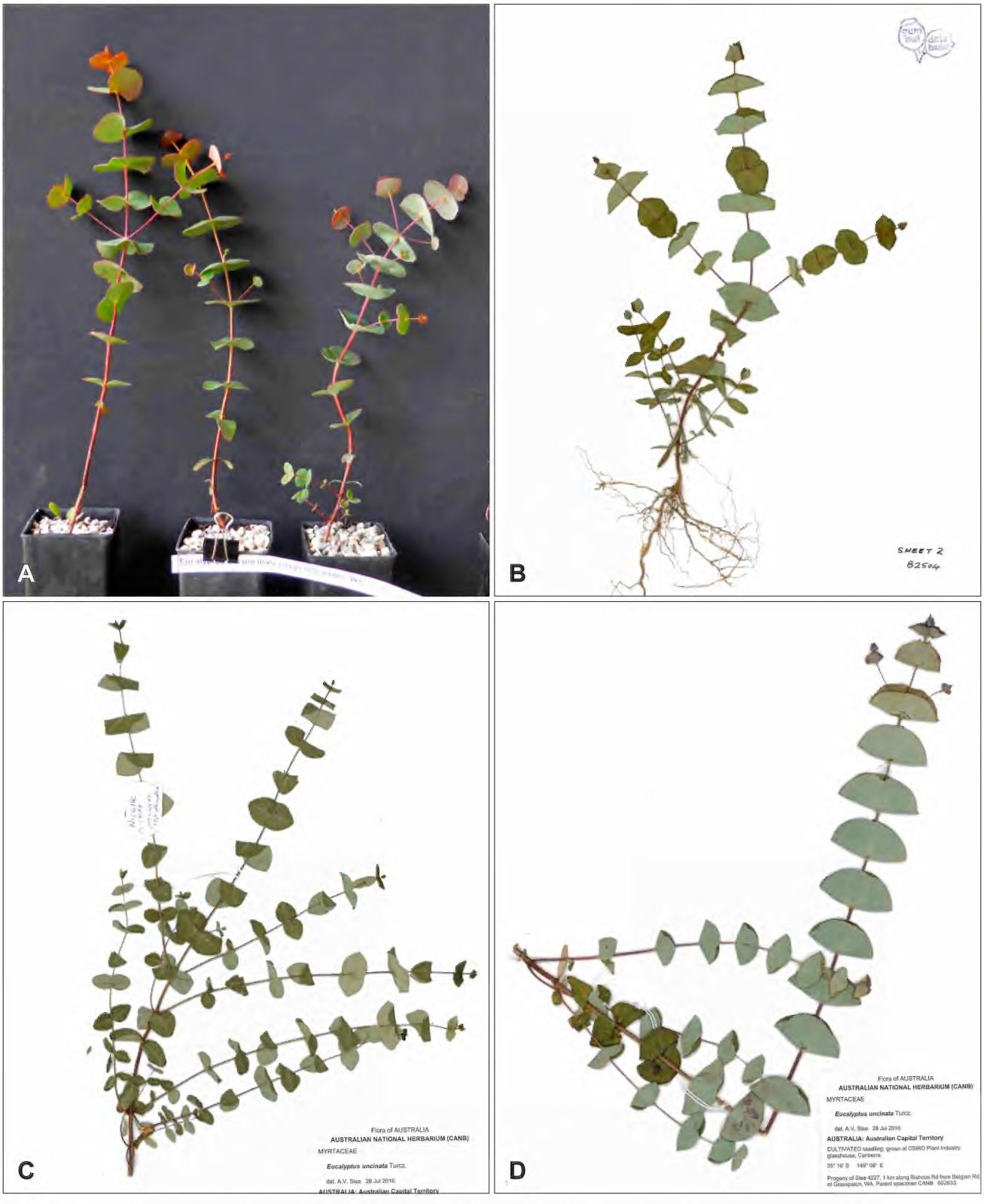

Fig. 50. *Eucalyptus connexa* seedlings. **A** F1 of *D. Nicolle 162*, Griffiths Rd, W of Coolgardie-Esperance Hwy, W.A.; **B** F1 of *M.I.H. Brooker 2504*, Scaddan, W.A.; **C** F1 of *D. Nicolle 1089*, Balladonia Rd, NW of Mt Ragged, W.A.; **D** F1 of *A.V. Slee 4227*, Bishops Rd, W of Grass Patch, W.A.

Distribution and habitat. Endemic to W.A., where it is apparently restricted to the subcoastal plain north and north-east of Esperance, from the Lort River catchment eastwards to near the Russell Range (Fig. 47). It grows on plains and in broad shallow depressions, often near salt lakes, in white to grey sand or red to grey-brown loam overlying limestone, in mallee shrubland or mixed mallee woodland. Associated eucalypts include *Eucalyptus assimilans*, *E. balladoniensis* subsp. *balladoniensis*, *E. dielsii*, *E. dolichorhyncha*, *E. eremophila*, *E. extensa*, *E. flocktoniae* subsp. *hebes*, *E. foliosa*, *E. forrestiana*, *E. fraseri* subsp. *fraseri*, *E. histophylla*, *E. incrassata*,

E. indurata, *E. kessellii*, *E. laevis*, *E. leptocalyx*, *E. melanoxylon*, *E. micranthera*, *E. obesa*, *E. occidentalis*, *E. oleosa* subsp. *cylindroidea*, *E. ovularis*, *E. platycorys*, *E. pleurocarpa*, *E. quadrans*, *E.* sp. Esperance, *E. terebra*, *E. tumida*, *E. urna*, *E. valens* and *E. varia*.

Conservation status. Not yet assessed under the IUCN Red List of Threatened Species (IUCN 2020). Considering its known distribution, life cycle, and threats, we believe that an IUCN Red List category of 'Near Threatened' is appropriate for the species.

Not a listed taxon under Conservation Codes for Western Australian Flora (Smith & Jones 2018). Recorded from Dundas, Scadden and Truslove nature reserves.

Etymology. The epithet is from the Latin *connexus* (a union of parts), referring to its conspicuous, consistently connate juvenile leaves.

Notes. *Eucalyptus connexa* was previously included in *E. uncinata*, but differs in more spaced, larger, consistently connate juvenile (seedling and coppice) leaves, its dull and blue-green new adult foliage, its generally smaller buds with shorter opercula, and its generally smaller, more globose to somewhat urceolate fruits with a smaller orifice. It also tends to be larger-growing, often reaching tree proportions, and typically has persistent, rough bark on the trunks, although these features of the habit and bark may be related to environmental conditions such as fire frequency. *Eucalyptus connexa* typically occurs on plains and in shallow depressions in limestone-derived soils, sometimes fringing salt lakes, but has also been recorded from low granite hills in the same region (e.g. Condingup Peak).

The distribution of *E. connexa* is imperfectly known, especially in the area west of the Lort River. *Eucalyptus uncinata* is not known within the distribution of *E. connexa* but occurs to both the west and the east in hillier areas closer to the coast (e.g. the Russell Range and the Wylie Scarp).

Selected specimens

WESTERN AUSTRALIA (west to east). Lake Tay to Peak Charles tk, 8 Sep. 2020, *M.E. French 3399* (PERTH); Peak Charles, S side, Roe District, 8 Sep. 1999, *A.V. Slee 4216* (AD, CANB, PERTH); NW of Esperance, Cascades Rd, c. 1 km SE of Field's Rd, 13 Sep. 1999, *A.V. Slee 4241* (CANB); beside Lort River, NW of the junction of major NW and NE branches of the river, 13 Nov. 1999, *W. O'Sullivan 823* (PERTH); corner of Rollond Rd and Belgian Rd, 18 Jan. 2021, *D. Nicolle 8012 & M.E. French* (PERTH); c. 1 km along Bishop's Rd from Belgian Rd, W of Grass Patch, 9 Sep. 1999, *A.V. Slee 4227* (CANB); Griffiths Rd, c. 2 km W of Coolgardie-Esperance Hwy, 6 Dec. 1992, *D. Nicolle 162* (AD); Scaddan, 15 Feb. 1970, *M.I.H. Brooker 2504* (CANB, MO, PERTH); c. 18 km E Dalyup, 28 Dec. 1979, *M.I.H. Brooker 6697* (CANB, PERTH); c. 49 km N of Esperance, 5 Apr. 1977, *M.I.H. Brooker 5655* (AD, CANB, NSW, MEL, PERTH); N of Esperance; on Norwood Rd, 12 Sep. 1999, *A.V. Slee 4239* (CANB); Sunrise Hill rd, E of Salmon Gums, 15 Apr. 2008, *M.E. French 2067* (PERTH); NE of Esperance on Dempster Rd, c. 10 km S of Speddingup Rd, 12 Sep. 1999, *A.V. Slee 4236* (CANB); Dempster Rd, NE of Esperance, 11 Jan. 2004, *M.E. French 1578* (PERTH); on tk which is a continuation of Dempster Rd c. 13 km N of Mt Ridley turnoff, 17 Nov. 1999, *W. O'Sullivan 854* (PERTH); W of Parmango Rd on tk heading due W to N end of Mt Ney track, 17 Jan. 2021, *D. Nicolle 7997 & M.E. French* (AD, PERTH); Balladonia Rd, NW of Mt Ragged, 21 Nov. 1994, *D. Nicolle 1089* (AD, CANB, PERTH); Condingup Peak, 18 Jan. 2021, *D. Nicolle 8006 & M.E. French* (PERTH); c. 15 km SE of Mt Ney road on Clyde Rock rd, 6 Nov. 1986, *K.D. Hill 2272 & L.A.S. Johnson* (CANB, MEL, NSW, PERTH); Mt Ragged-Balladonia tk, 16 Apr. 2008, *M.E. French 2077* (PERTH); c. 142 km S of Balladonia, SW of Mt Ragged, 3 Apr. 1977, *M.I.H. Brooker 5638* (AD, CANB, NSW, MEL, PERTH); c. 123 km S of Balladonia, SW of Mt Ragged, 3 Apr. 1977, *M.I.H. Brooker 5632* (AD, CANB, MEL, PERTH); c. 15 km W of Balladonia turnoff on Israelite Bay rd, 3 Apr. 1977, *M.I.H. Brooker 5641* (AD, CANB, NSW, MEL, PERTH).

23. *Eucalyptus albida* Maiden & Blakely

J. & Proc. Roy. Soc. New South Wales 59: 175–177 (1925). — **Lectotype:** Harrismith, Western Australia, 6 Mar. 1924, *C.A. Gardner 2113* (NSW350710), *fide* Chippend., *Fl. Austral.* 19: 285 (1988), as "holo". **Isotypes:** MEL; PERTH.

Mallee to 7 m tall; lignotuber present, lignotuber resprouter (Nicolle 2006). *Bark* usually smooth throughout, decorticating annually in strips, grey over orange or pink to pale yellow to powdery white. Larger individuals may have some persistent bark on the trunks up to 2 m. *Branchlets* non-pruinose. *Seedling leaves* opposite for numerous pairs, on nodes 4–14 mm apart, sessile, orbicular to cordate, 10–20 mm long × 10–20 mm wide, length:width ratio typically 1–1.2:1, concolorous, dull, greyish, strongly pruinose. *Coppice leaves* similar but typically larger, narrower and more spaced. *Mature crown* composed entirely of adult leaves (although juvenile coppice is sometimes conspicuous on damaged trunks). *Adult leaves* with petioles 6–16 mm long, lamina narrow-lanceolate to lanceolate (to broad-lanceolate), 40–90 mm long × 5–15 mm wide, length:width ratio typically 4–9:1, very glossy, green to yellow-green, non-pruinose; tertiary venation dense; oil glands numerous, connected to vein network (intersectional oil glands). *Inflorescences* 7–11-flowered; peduncles terete to angular in cross section, 6–18 mm long; pedicels 2–8 mm long. *Flower buds* ovoid, 6–9 mm long × 3.5–7 mm diam.; opercula bluntly conical to hemispherical, often apically flattened, 3.5–5.5 mm long, length:width ratio typically 1–1.5:1. *Flowers* with a twisted style. *Fruits* obconical to cupular (to truncate-globose), 4–7 mm long × 5–7 mm diam.; disc level to descending; valves 3 or 4, below rim level.

Diagnostic characters. Distinguished within *E.* ser. *Porantherae* by the following combination of characters: Lignotuberous mallee. Bark mostly smooth and

Fig. 51. *Eucalyptus albida* seedlings. **A** F1 of *D. Nicolle 2214*, Marchagee Track, N of Watheroo, W.A.; **B** F1 of *D. Nicolle 3699 & M.E. French*, Coorow-Green Head Rd, SW of Coorow, W.A.; **C** F1 of *A.V. Slee 4076*, W of Corrigin, W.A.; **D** F1 of *D. Nicolle 3437 & M.E. French*, E of Pingaring-Varley Rd North, W.A.

shedding. Branchlets non-pruinose. Seedling leaves opposite for numerous nodes, orbicular to cordate (length:width ratio 1–1.2:1), strongly pruinose (Fig. 51). Adult leaves narrow-lanceolate to lanceolate (to broad lanceolate) (length:width ratio 4–9:1), very glossy. Pedicels distinct. Opercula bluntly conical to rounded and apically flattened. Fruits obconical to hemispherical.

Illustrations. M.I.H. Brooker & D.A. Kleinig, *Field Guide Eucalypts* 2: 313 (1990); 2nd edn, 2: 313 (2001); 3rd edn, 2: 287 (2016); A.V. Slee *et al.*, *EUCLID Eucalypts of Australia* CD ROM, *Eucalyptus albida* (2006); M.E. French, *Eucalypts W. Austral. Wheatbelt* 266, 267 (2012); M.E. French & D. Nicolle, *Eucalypts W. Austral. – S.W. Coast & Ranges* 222, 223 (2019).

Distribution and habitat. Endemic to W.A., where it is mainly distributed in the central and southern wheatbelt of Western Australia, from east of York south-eastwards to Fitzgerald River National Park. Disjunct populations occur on the northern sandplains from north-east of Eneabba to north-east of Badgingarra (Fig. 47). The species occurs on white to pale yellow sand or lateritic gravel, often as an emergent in low shrubland. Associated eucalypts include *Eucalyptus drummondii*, *E. falcata*, *E. gardneri*, *E. gittinsii* subsp. *illucida*, *E. incrassata s.lat.*, *E. micranthera*, *E. obesa*, *E. phaenophylla*, *E. pleurocarpa*, *E. pyriformis*, *E. redunca* subsp. *pluricaulis*, *E. thamnoides*, *E. uncinata* subsp. *uncinata* and *E. wandoo* subsp. *wandoo*.

Conservation status. Globally listed as 'Vulnerable' on the IUCN Red List of Threatened Species (IUCN 2020). This assessment appears to overstate the actual risk to the species, which is widespread, represented in several large reserves, and currently has stable population numbers. Considering its known distribution, life cycle, and threats, we believe that an IUCN Red List category of 'Near Threatened' is more appropriate for the species.

Not a listed taxon under Conservation Codes for Western Australian Flora (Smith & Jones 2018). The species has been recorded from Alexander Morrison, Fitzgerald River and Watheroo national parks and from Birdwhistle, Boolanelling, Merilup, Dragon Rocks, Silver Wattle Hill and Tarin Rock nature reserves.

Common names. White-leaved Mallee (Chippendale 1988; Slee *et al.* 2006; French 2012; Brooker & Kleinig 2016; French & Nicolle 2019).

Notes. *Eucalyptus albida* is a well-defined species. Its circumscription has not been modified by this revision. The species is somewhat isolated within *E.* ser. *Porantherae*, with its twisted style distinguishing it from all other species in the series. The species has perhaps the greyest, most pruinose seedling and juvenile leaves and the glossiest adult leaves of all species in *E.* ser. *Porantherae*, such that individuals are very striking in the field when transitioning from juvenile to adult leaves.

Eucalyptus albida could be confused with *E. dissimulata*, which differs most notably in its non-pruinose, greenish juvenile (seedling and coppice) foliage. *Eucalyptus dissimulata* also differs from *E. albida* in its consistently non-powdery bark, its more uniform canopy (not patchy or tiered), its more pointed opercula and its straight style in the bud. There are many other differences in the bark, adult leaves, buds and fruits, but these are relatively subtle and require much experience to reliably discriminate the two species.

Selected specimens

WESTERN AUSTRALIA (north to south). Chatfield Clarke Rd, SW of Coorow, 8 Dec. 2011, *M.E. French 2224* (PERTH); Alexander Morrison N.P., 3 Feb. 1985, *M.I.H. Brooker 8811* (CANB, PERTH); Marchagee Tk, N of Watheroo, 18 Apr. 1998, *D. Nicolle 2214* (PERTH); Coorow to Green Head rd, SW of Coorow, 13 Jan. 2001, *D. Nicolle 3699 & M.E. French* (PERTH 05810604); c. 5 miles S of Tammin, 5 Mar. 1967, *G.M. Chippendale 78* (AD, CANB, PERTH); c. 6 km from Albany Highway on Dardadine Rd South, 26 Jan. 2001, *D. Nicolle 3734 & M.E. French* (CANB, PERTH); c. 4 km W of Corrigin, 27 Apr. 1999, *A.V. Slee 4076* (CANB); Whittington Rd, Corrigin, 2 Nov. 1997, *R. Campbell 561* (AD, PERTH); Tees Rd, NE of Nyabing, 13 Dec. 1999, *M.E. French 1110* (PERTH); E of Pingaring-Varley North Rd, 16 Sep. 2000, *D. Nicolle 3437 & M.E. French* (PERTH); Old Ravensthorpe Rd, near Tuck Rd, between Andler Rd and Neld Rd, Coolgardie District, 4 Sep. 1999, *A.V. Slee 4194* (AD, CANB, PERTH); Hamersley Drive, SW of Ravensthorpe, Fitzgerald River N.P., 8 Jan. 2017, *M.E. French 2926* (PERTH).

Hybrids and intergrades

Eucalyptus austrina – E. olivina intergrades

Selected specimens

WESTERN AUSTRALIA. c. 30 km NW of Ravensthorpe on Lake King rd, 23 Nov. 1994, *D. Nicolle 1118* (AD).

Eucalyptus ecdysiastes – E. foecunda intergrades

Selected specimens

WESTERN AUSTRALIA. Red Gully Rd, SW of Mogumber, 7 Aug. 2013, *M.E. French 2631* (PERTH).

Eucalyptus ecdysiastes – E. horistes intergrades

Selected specimens

WESTERN AUSTRALIA (west to east). 5 km S of Miling, 3 Nov. 1985, *M.I.H. Brooker 9053* (CANB, PERTH); 3.3 km E of Siberia Davyhurst Rd near far western boundary of Goongarrie Station, SW Menzies, 30 Jan. 2021, *M.E. French 3223* (PERTH); W of Kanandah Station, E of Kalgoorlie, NE of Kitchener, 31 Mar. 2013, *M.E. French 2629* (PERTH); Kitchener to Tjuntjunjara rd, W of Cable Haul Rd, 29 Apr. 2015, *D. Nicolle 6958 & M.E. French* (holo: PERTH; iso: AD, CANB); Cable Haul Rd, S of PNC Baseline Rd, 28 Apr. 2015, *D. Nicolle 6951 & M.E. French* (AD, PERTH); c. 79 km S from N end of Cable Haul Rd, 28 Oct. 2019, *D. Nicolle 7831 & M.E. French* (PERTH).

Eucalyptus ecdysiastes – E. latens intergrades

Selected specimens

WESTERN AUSTRALIA. SE edge of Birdwhistle Nature Reserve SW of Wickepin, 10 Sep. 2014, *M.E. French 2713* (PERTH).

Eucalyptus ecdysiastes – E. lunata intergrades

Selected specimens

WESTERN AUSTRALIA. Between Lake Grace and Newdegate, 21 Jan. 2001, *D. Nicolle 3722 & M.E. French* (PERTH, CANB).

Eucalyptus efflorescens – E. horistes intergrades

Selected specimens

WESTERN AUSTRALIA (west to east). Just E of Bencubbin-Kellerberrin Rd, N of Trayning, 22 Aug. 2014, *M.E. French 2704* (PERTH); Sutton Rd, NE of Kununoppin, 22 Aug. 2014, *M.E. French 2705* (PERTH); Sutton Rd, NE of Kununoppin, 19 Mar. 2010, *D. Nicolle 5454 & M.E. French* (PERTH); Beringbooding Rd, ESE of Bonnie Rock, 1 Apr. 2010, *D. Nicolle 5605 & M.E. French* (PERTH).

Eucalyptus formanii subsp. *formanii* – subsp. *circulata* intergrades

Selected specimens

WESTERN AUSTRALIA. On track to Mount Manning Ra., 14 km E of Bullfinch-Evanston Rd, NE of Bullfinch, 21 May 2020, *M.E. French 3351* (PERTH).

Eucalyptus kumarlensis – E. salicola intergrades

Selected specimens

WESTERN AUSTRALIA. E shore of small salt lake c. 23 km S of Norseman on Hwy 1, 7 Sep. 1999, *A.V. Slee 4207* (CANB).

Eucalyptus latens – E. olivina intergrades

Selected specimens

WESTERN AUSTRALIA (north to south). Sorensens N.R., NE of Corrigin, 1 Nov. 2016, *M.E. French 2903* (PERTH);

Boundary Rd, SE of Harrismith, 12 Nov. 2014, *M.E. French 2751* (PERTH).

Eucalyptus lunata – *E. olivina* intergrades

Selected specimens

WESTERN AUSTRALIA (west to east). Kulin-Lake Grace Rd, SE of Kulin, 21 Oct. 2014, *M.E. French 2741* (PERTH); Kerrigan Rd, SE of Hyden, 12 July 2014, *M.E. French 2687* (PERTH).

Eucalyptus rigidula subsp. *clancularia* – subsp. *interior* intergrades

Selected specimens

WESTERN AUSTRALIA (west to east). 21.1 km from Zanthus to Balladonia tk near Spy Hill on the Fraser Ra. Station tk, 9 Nov. 2000, *D. Nicolle 3630 & M.E. French* (AD, CANB, PERTH); Cundeelee Rd, just NW of Zanthus, 20 Jan. 2021, *D. Nicolle 8026 & M.E. French* (PERTH); c. 28 km S of Zanthus towards Balladonia, 25 July 1999, *J. Connors 1064 & D. Nicolle* (CANB); c. 28 km by rd S of Transcontinental railway line near Zanthus towards Balladonia Roadhouse, 25 July 1999, *D. Nicolle 2786 & J. Connors* (AD, CANB).

Eucalyptus olivina – *E. perangusta* intergrades

Selected specimens

WESTERN AUSTRALIA (north to south). Beatty Rd, 7 Jan. 2007, *D. Nicolle 5054 & M.E. French* (CANB, PERTH).

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Hibbertia mathinnicola (Dilleniaceae), a new endemic species from northeastern Tasmania

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Abstract: *Hibbertia mathinnicola* M.Wapstra is described and illustrated as an endemic taxon that is highly localised to northeastern Tasmania. Plants of this species have previously been identified as *Hibbertia calycina* (DC.) N.A.Wakef., a species now considered restricted to mainland Australia.

Keywords: *Hibbertia*, new species, *Hibbertia calycina*, endemic, taxonomy, northeast Tasmania, threatened species

Introduction

Hibbertia Andrews is a genus of more than 300 species, distributed mainly in Australia and extending to New Caledonia, New Guinea, Madagascar and some Pacific islands (APNI 2021). The number of species recognised in Tasmania has been somewhat fluid, especially in recent years as the taxonomy of some species-complexes of southeastern Australia has been resolved (e.g. Toelken 1998, 2000, 2013). Tasmania currently has eighteen species of *Hibbertia* (de Salas & Baker 2021), one of which is recognised as endemic, *Hibbertia basaltica* (Buchanan & Schahinger 2005).

One of the eighteen species recognised for Tasmania by de Salas & Baker (2021) is *Hibbertia calycina* (DC.) N.A.Wakef. The species is not listed as endemic, as it also occurs in Victoria (Willis 1972; Toelken 1996) and New South Wales (Harden & Everett 1990), including the Australian Capital Territory (Burbidge & Gray 1970). The recognition in other State floras that "*Hibbertia calycina*" also occurred in Tasmania is a relatively recent development. For example, Toelken (1996) in the *Flora of Victoria*'s treatment of *Hibbertia* did not attribute the species to Tasmania, although the current online version now does.

Hibbertia calycina was not included in any of the versions of *The Student's Flora of Tasmania*, Part 1 (Curtis & Morris 1975), since the Tasmanian Herbarium did not hold any specimens attributable to the species until the early 1980s. That such a distinctive species apparently went overlooked (or at least not collected) for close to two centuries of European occupation is somewhat surprising, especially given the early focus on the flora of the greater St Helens region in the late 1800s. In fact, it was in 1892 that Fitzgerald collected *Hibbertia rufa* from the area, which was to go unnoticed again until 2008, when the species was found to be localised but often abundant (Wapstra *et al.* 2011), highlighting how distinctive taxa can remain overlooked.

Prior to the recent submission of a batch of voucher specimens from surveys conducted in 2003/2004 by the author, the Tasmanian Herbarium (HO) only held eight sheets of *Hibbertia calycina*, the earliest from 9 Oct. 1980, three from 15 Jun. 1981, one from 8 Aug. 1981, and one each from 19 Oct. 1993, 6 Apr. 1995 and 20 Sep. 1999. The specimens from 1981 were originally labelled "*Hibbertia ?cistiflora*", presumably reflecting the use of a mainland flora treatment to identify the specimens (A. Buchanan, pers. comm.), but all subsequent specimens were labelled as "*Hibbertia calycina*". The Queen Victoria Museum & Art Gallery (QVMAG) also holds five collections of the taxon, two of which are apparent duplicates of one another (both labelled "Upper Scamander Pitts Hill", dated 9 Oct. 1980, and attributed to Mary Cameron), these being probably duplicates of the specimen held at the Tasmanian Herbarium with the same date and location. Of note is that these specimens are labelled "first recording for Tasmania". Other collections held at QVMAG include two from 20 Aug. 1981, attributed to "Forestry Officers" and one from 29 Sep. 1987 (also a Mary Cameron collection).

The impetus for the present paper was a long-term project examining the conservation status of "*Hibbertia calycina*" in Tasmania, started in 1995, and reported in Hopkins (1996), because of the taxon's restriction to wood production forests and uncertainty regarding its distribution, habitat and management requirements. That ecological project was continued and is reported in Turner *et al.* (2020), which describes the

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distribution, habitat, population structure, management requirements and conservation status of the taxon (as *Hibbertia calycina*). It has been long-speculated that the Tasmanian "*Hibbertia calycina*" was a distinctive endemic taxon, principally supported by the restricted distribution and unique habitat, and morphological differences. Examination of *Hibbertia* material in HO showed it to be distinct from any named species. The formal recognition of this taxon is now made.

Materials and methods

The description of the new species is based on wild-collected material by the author and on specimens held at HO. Examination of root material was made on small plants, 3–15 cm tall with measurements taken at a depth of 1–2 cm below ground level. Seed was examined from material stored in the collections of the Tasmanian Seed Conservation Centre.

Taxonomy

Hibbertia mathinnicola Wapstra, ***sp. nov.***

Holotypus: Skyline Tier, Scamander Forest Reserve, 19 Oct. 1983, *F. Duncan s.n.* (HO322826). **Isotypi:** AD, HO322827.

Hibbertia calycina auct. non (DC.) N.A.Wakef.: M.Wapstra *et al.*, *Little Book Common Names Tasman. Pl.* 23 (2005); A.M.Gray, *Fl. Tasmania Online Dilleniac.* 25 (2009); de Salas & Matthew.L.Baker, *Cens. Vasc. Pl. Tasmania* 40 (2020); Turner *et al.*, *Pap. Proc. Roy. Soc. Tasmania* 154: 61 (2020).

Erect *shrub* to 0.3–0.6 (–1.3) m high, multi-stemmed, sometimes from the base, generally dense and compact with well-developed taproot, c. 2–4 mm diam. and several finer lateral roots (c. 0.4–0.6 mm diam.). *Branches* with many short lateral shoots, sparsely strigose, glabrescent; stem hairs tubercle-based, short, simple, very rarely bifurcate or multi-branched. *Leaves* alternate but closely clustered (almost fasciculate), erect, dark green when fresh, rarely yellowing in highly exposed situations, drying grey-green; stomata highly visible in dried material; petiole very short; lamina (3.5–) 10–15 (–18) mm long (leaves in close groups tend to be shorter, while older leaves at the end of flowering branchlets tend to be in the 14–16 mm length range), 0.75–1.2 mm wide, linear; margins revolute, raised above and touching a broad central ridge that extends to the apex; adaxial surfaces with scattered tubercle-based, forward-directed, simple, acicular hairs; abaxial surfaces obscured by the in-rolled margins; true abaxial leaf surface with abundant short multi-cellular white hairs (visible by dissection). *Flowers* 5-merous, solitary, sessile, terminal on short lateral branches. *Bracts* in pairs, narrowly triangular, fawn-brown, sparsely strigose, c. 3 mm long, c. 0.8 mm wide at the base, gently to deeply curved with long-tapered apex. *Sepals* imbricate, persistent, light green, occasionally with purple-brown flecks and patches, 4.5–6.5 mm long, unequal; outer sepals narrow-ovate, inner sepals broadly-ovate; sepal adaxial surfaces sparsely to moderately strigose on exposed surfaces; abaxial surfaces glabrous to sparsely strigose in upper quarter to third; margins of inner sepals membranous and virtually glabrous except for short scattered hairs; sepal apex shortly apiculate (apiculum 0.8–1 mm long). *Petals* bright yellow, often all present on most flowers at full anthesis but rapidly caducous, spreading, oblong-obovate, 7–8.5 mm long with a 1 mm long notch at the apex. *Stamens* 8–10, without staminodes, in a single cluster to one side of the carpels, erect, c. 3 mm long; filaments slightly connate at the base; anther and filament ± equal; anthers dehiscing by vertical slits. *Carpels* 2, fused at base; ovaries tomentose to villous, styles attached at the dorsal apex of each ovary, erect, c. 4–4.3 mm long. *Seeds* reniform, slightly flattened, 1.5–2.2 mm long, 1.2–1.6 mm wide, smooth, red-brown. **Figs 1–5.**

Fig. 1. Habit of *Hibbertia mathinnicola*, also showing the typical habitat of exposed ridgeline-upper slope topography in open *Eucalyptus sieberi* forest (Skyline Tier, 3 Sep. 2018).

Fig. 2. Abaxial and adaxial views of dried leaves of *Hibbertia mathinnicola*, showing the strigose leaves with mucro (shortest leaf c. 10 mm long). — *M. Wapstra 2669 et al.* (HO).

Fig. 3. Flower of *Hibbertia mathinnicola* in cultivation, Royal Tasmania Botanic Gardens, 15 Sep. 2017 (based on material vouchered as *J. Wood 124*, HO), showing the eight stamens clustered on one side of the ovary.

Fig. 4. Dried flower of *Hibbertia mathinnicola*, showing the tomentose to villous ovary surface and moderately strigose sepals. — Holotype.

Fig. 5. Seed of *Hibbertia mathinnicola* from seed orchard, Royal Tasmanian Botanical Gardens, 3 May 2021 (based on material vouchered as *J. Wood 124*, HO). — Photo: J. Wood.

Diagnostic characters. *Hibbertia mathinnicola* is distinguished from *H. calycina* as follows: *Hibbertia mathinnicola* is usually a larger shrub to 1.3 m high [vs *H. calycina*, a smaller shrub or shrublet to 0.7 (–1) m high] with longer leaves, (3.5–) 10–15 (–18) mm [vs (3–) 4–10 (–15) mm], and slightly longer sepals, 4.5–6.5 mm [vs (4.5–) 5–6 mm]. The bracts of the new species are distinctive, being narrowly triangular with a long drawn-out tip and often over 3 mm long [vs triangular to lanceolate bracts, to 2.6 mm, with a blunt to acute tip] (H.R. Toelken, pers. comm., 2021; Toelken 1996).

Remarks. *Hibbertia calycina* does not occur in Tasmania. That species was described as *Pleurandra calycina* by A.P. de Candolle (1817) with the type given as "Hab. In Novae-Hollandiae montibus, Caley. (v.s. sp. in h. Lamb.)" and combined in *Hibbertia* by Wakefield (1955), with no notion that the type was from Tasmania.

Within Tasmania, *Hibbertia mathinnicola* is superficially most similar to *H. riparia*, although any resemblance between the two species is obscure and superficial, and confusion simply does not arise in either the field nor curated herbarium collections. The key to *Hibbertia* species provided in the *Flora of Tasmania Online* (Gray 2009) separates the two species (*H. mathinnicola* included as *H. calycina*) on the arrangement of the leaves ("densely crowded on short lateral branchlets; length:breadth ratio 10–15/1; apex blunt or mucronate" for "*H. calycina*" and "not densely crowded, well dispersed; length:breadth ratio (3–)5(–10):1; apex acute-apiculate" for *H. riparia*). This should be corrected to indicate that the apex of the leaves of *H. mathinnicola* is acute-apiculate (when fresh, almost pungent) and the apex of the leaves of *H. riparia* is acute to obtuse but not apiculate (and when fresh, never almost pungent). *Hibbertia mathinnicola* is an erect, densely branched (sometimes from the base, especially after fire), compact shrub with dark green linear leaves that are tuberculate (hairy to varying degrees depending on age) and, especially when fresh, with a distinctive apiculate mucro that is almost pungent in fresh material, the leaves having a distinct prickly feel and appearance, particularly so on drying), the flowers with 8–10 stamens in a single cluster on one side of the carpels, the ovaries tomentose to villous.

Distribution. *Hibbertia mathinnicola* has a restricted distribution in the hinterlands of the northeast coast of Tasmania between Scamander and St Helens (Fig. 6). It is known from nine closely-clustered patches of plants associated with ridge systems that are disconnected from one another (Turner *et al.* 2020). Its extent of occurrence (minimum convex polygon) is approximately 95 km² with an area of occupancy of c. 0.43 km² and an estimated abundance of over 15,000 plants (Turner *et al.* 2020).

Habitat. The species occurs in dry sclerophyll forest dominated by *Eucalyptus sieberi* L.A.S.Johnson

Fig. 6. Distribution of *Hibbertia mathinnicola* in Tasmania.

(Tasmanian ironbark) with a very open understorey on Ordovician-Devonian turbiditic sedimentary sequences known as the Mathinna Supergroup. The species is restricted to highly insolated ridges and adjacent slopes, which are often very steep, sometimes loosely and densely rocky (Fig. 1). It has been recorded from elevation ranges from 110 to 375 m a.s.l.

Phenology. Flowers present throughout most of year, peaking from November to April.

Etymology. The epithet *mathinnicola* is a composite of the word Mathinna and Latin *-cola* (dweller), recognising that the species is wholly restricted to ridgelines and adjacent slopes on the uniquely Tasmanian sedimentary substrate known as the Mathinna Supergroup (Calver *et al.* 2014).

Suggested common name. The name ironbark guineaflower is suggested in recognition of the habitat of the species (restricted to *Eucalyptus sieberi*, Tasmanian ironbark, forests). In Tasmania, this taxon has been previously known as the lesser guineaflower (Wapstra *et al.* 2005–), but this name should be reserved for mainland Australian material of *H. calycina*.

Reservation status. *Hibbertia mathinnicola* occurs only on public land (Turner *et al.* 2020). Some populations are within legislated reserves including the German Town Regional Reserve and Scamander Regional Reserve, but most sites are within public land currently designated as Future Potential Production Forest (Informal Reserve), the status of which is somewhat uncertain pending political decisions on the forest industry in Tasmania.

Conservation status. *Hibbertia mathinnicola* has been listed (as *Hibbertia calycina*) as vulnerable (Schedule 4) on the *Tasmanian Threatened Species Protection Act 1995* since the promulgation of the Act. A review of the conservation status by Turner *et al.* (2020) concluded this status remains valid, pending a more thorough population estimate. Given it is a narrow-range endemic species, *H. mathinnicola* is likely to qualify as Vulnerable or Endangered on the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

Additional specimens examined [ordered by date of collection and then c. north to south]

TASMANIA. Upper Scamander on Pitts Hill and Pyramid Hill, 9 Oct. 1980, *M.P. Cameron s.n.* (HO36335); Pyramid Hill, 2 km N of Upper Scamander, 15 June 1981, *A. Moscal 795* (HO); Loila Tier, c. 1 km SW of Loila Pinnacle, 15 June 1981, *A. Moscal 796* (HO); Pyramid Hill, 8 Aug.1981, *F. Duncan s.n.* (HO329905); McIntyre Creek catchment, 6 Apr. 1995, *F. Duncan s.n.* (HO411630); St Helens area, 20 Sep. 1999, *T.W. Dudley s.n.* (HO501301); Skyline Tier, 6 Nov. 2002, *M. Wapstra s.n.* (pers. herb.); Trout Road, Scamander, 17 Dec. 2009, *J. Wood 124* (HO); between Bolpeys Ridge and Catos Road (catchment of Wattle Creek), 13 Nov. 2017, *M. Wapstra 2674 & P. Turner* (HO); Mt Echo (NE of), above Nephele Creek, 14 Nov. 2017, *M. Wapstra 2676, P. Turner & K. Hopkins* (HO); NE of Mt Echo (catchment of Constable Creek), 14 Nov. 2017, *M. Wapstra 2673, P. Turner & K. Hopkins* (HO); Mt Echo, northwest ridge, 14 Nov. 2017, *M. Wapstra 2671, P. Turner & K. Hopkins* (HO); Skyline Tier (near S. end), 14 Nov. 2017, *M. Wapstra 2675, P. Turner & K. Hopkins* (HO); north of Wolfram Creek Track, catchment of Fitzgerald Creek, 15 Nov. 2017, *M. Wapstra 2669, P. Turner & K. Hopkins* (HO); NW of Orieco Hill, SW of Orieco Road, catchment of Eastern Creek, 15 Nov. 2017, *M. Wapstra 2672, P. Turner & K. Hopkins* (HO); Pyramid Hill (continuation of ridge to W of main hill), 15 Nov. 2017, *M. Wapstra 2670, P. Turner & K. Hopkins* (HO); Trout Road, NW of Pitts Hill, 15 Nov. 2017, *M. Wapstra 2665, P. Turner & K. Hopkins* (HO); immediately west of Loila Track (headwaters of Fitzgeralds Creek), 16 Nov. 2017, *M. Wapstra 2668, P. Turner, K. Hopkins & R. Skabo* (HO); SE of Orieco Hill (c. 6 km W of Beaumaris), 16 Nov. 2017, *M. Wapstra 2667, P. Turner, K. Hopkins & R. Skabo* (HO); SE of Orieco Hill (c. 6 km W of Beaumaris), 16 Nov. 2017, *M. Wapstra 2666, P. Turner & K. Hopkins* (HO).

Discussion

Hibbertia mathinnicola is a distinctive shrub that occurs in a locally restricted part of the northeast coastal hinterlands of Tasmania in highly distinctive (and predictable) habitat. The species has been long-recognised as unique amongst the Tasmanian *Hibbertia* and suspected as being an endemic species. This description of the taxon hitherto known as *Hibbertia calycina* in Tasmania adds to the list of narrow-range endemics for the State, their restricted range apparently controlled to a large extent by the underlying geology. *Hibbertia basaltica* is another such narrow-range

endemic within the genus, restricted to Tertiary basalt, and possibly Jurassic dolerite, in southeast Tasmania (Toelken 2013; Buchanan & Schahinger 2005). Within Tasmania, there are several vascular plant species confined to particular geological substrates including Jurassic dolerite, mainly on the central east coast; Devonian granites and granodiorites (again, mainly on the east coast); and Cambrian ultramafics often referred to as serpentine (localised occurrences on the west coast and north coast). There are few vascular plant species, however, wholly associated with sedimentary substrates, especially the Mathinna Group turbidite sequences of the northeast of Tasmania: *Hibbertia mathinnicola* may be unique in this respect.

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